The Journal of ENGINEERING EDUCATION

January, 1959 *Table of Contents* Vol. 49, No. 4

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DO YOU KNOW . . . .

► . . . . That after 38 years we can say it again?

1. Everyone should be a member of the Society that represents his profession. The first estimate of the teacher of engineering is often made by the membership list of this Society. The reputation of the men whose names are found there gives real prestige to every teacher who is a member.

2. Every live teacher should possess the technical information on teaching made available through the JOURNAL OF ENGINEERING EDUCATION, the publication of the American Society for Engineering Education.

3. The up-to-date teacher, as never before, must meet with other teachers to discuss the live problems of his profession.

4. One should do something for his own profession. The American Society for Engineering Education is doing great work for engineering education, and every man in that profession should do his part.

5. The young men of today will be the leaders of the profession tomorrow. Therefore, let every young, growing, progressive engineering teacher ask himself these questions: "Can I afford not to be a member of the American Society for Engineering Education? Can I afford not to enroll in the ranks of successful members of my profession? Can I afford to stand idly by while others no better qualified reach preferment? Can I afford to belong to a profession if I do not strive to make it broader, better, and brighter, by my own individual efforts?"

Except for the name of the Society and the name of the *Journal*, the above material is an exact quote from the program for the 29th Annual Meeting of the Society at Yale University in 1921. The program was thoughtfully sent to the Secretary by L. W. Hitchcock, Professor Emeritus at the University of New Hampshire.

► . . . . That the country's noncommercial educational television stations have nearly doubled production of programs in science and technology during the past year? A news release from the Educational Television and Radio Center of Ann Arbor, Michigan, states that six new stations are in operation since the spring of 1958 and that the majority of stations are increasing the daily period of broadcasting. It says that the most outstanding change in ETV programming this year is reflected in the large increase in programs designed to teach course material to classroom students. Grants from the Fund for the Advancement of Education have stimulated these TV-teaching programs.

► . . . . That an Educational Television Newsletter is published by the committee on Television of the American Council on Education? Those interested in this new educational tool, either on an open or closed circuit basis, will find much interesting information and many valuable references to recent reports in its four pages. The address of ACE is 1785 Massachusetts Ave., N. W., Washington, D. C.

► . . . . That the National Defense Education Act authorizes three million dollars for the first year and five million dollars for each of the three succeeding years to support research projects in educational television, radio and motion pictures, and related communications media? The Office of Education is prepared to consider applications for funds. They should be sent to the Director, Communica-

tions Media Research Program, Office of Education, Department of Health, Education, and Welfare, Washington 25, D. C. The Office of Education also has sponsored a meeting of representatives of interested organizations for the purpose of designing a broad framework for research in this educational area.

► . . . . That the young engineering teachers of the North Midwest Section had their own two-day meeting for the fifth time? There were a total of forty-four registrants with twenty-six coming from institutions other than the University of Wisconsin. The program had as its theme "The Young Engineering Teacher—His First Five Years of Professional Development." The meeting was held in conjunction with the meeting of the North Midwest Section at Madison, Wisconsin. The formal presentations and discussions centered on the responsibility of the individual, what industry can do, and what the institutions can do. Perhaps this successful plan contains some elements for other Sections to adopt.

► . . . . That the RWI Division is interested in the study of migration of engineers from industry to faculties? One large corporation informally reported that in a year's time 12 were lost and 7 gained; another reported that 38 were lost and 25 gained.

► . . . . That the RWI Division also is interested in a study of "professional climate"? Much of the recent meeting of its steering committee was devoted to a discussion of its meaning, an understanding of it, and its achievement. Professor J. M. English of UCLA has been named chairman of a committee to define and discuss this problem. There are many intangibles, but the right professional climate means that each man is challenged to his fullest. The attitudes of both management and the individual are involved, and education, too, has some responsibilities.

► . . . . That the College-Industry Conference is being held at Houston, Texas on Jan. 26 and 27? The theme is "Industry Speaks Its Mind on Engineering Education." On Monday morning there will be discussions on four aspects of the theme, on Monday afternoon there will be group meetings for the discussion of each aspect, and on Tuesday morning a general meeting to correlate the discussions of the previous day. The four general aspects are scientific vs. production viewpoints; the team concept; federal, corporation, and private practice; and obsolescence in engineers.

► . . . . That UPADI—*Union Panamericana de Asociaciones de Ingenieros* or the Pan-American Association of Engineering Societies—recently published the first list of the colleges of engineering in each of the 22 member countries? The curricula offered by each also are tabulated. There are 91 schools outside the U. S., 19 being in Mexico, 15 in Columbia, 13 in Brazil, and 12 in Canada. For the U. S. the schools having ECPD accredited curricula are listed. Copies of the booklet, in Spanish, may be obtained at no cost from Engineers Joint Council, the U. S. representative of the engineering societies.

W. Leighton Collins
Secretary

ASEE MISSIONS ABROAD

MISSION TO INDIA

The Government of India, through its Ministry of Scientific Research and Cultural Affairs, has requested technical advice and assistance in formulating plans to establish a new institute of technology at Kanpur, in northern India. At the request of the International Cooperation Administration, ASEE has furnished this assistance in the form of a team of six experienced educators in the engineering field going to India for a period of two months beginning November 27, 1958. The general headquarters of the group is New Delhi, but a number of other institutions, as well as Kanpur, are being visited.

During its visit the group is conferring with appropriate Indian officials to develop, discuss, and evaluate plans of the Government of India for the expansion of engineering education, particularly the establishment of the technical institute at Kanpur. If the establishment of the institute is desirable, the group will prepare a comprehensive report giving recommendations for the pattern of the proposed institution with respect to size, physical plant, laboratory facilities, organization, curricula, teaching methodology, educational philosophy, examination system, library, personnel services, recreation facilities, and all other details involved in the establishment of such an institute. This report is to be submitted prior to leaving India.

If the preliminary report is acceptable to the Government of India, a second, more detatiled report will be prepared after the group has returned to the United States. This will consist of preliminary plans for grounds, buildings, and equipment, and an estimate of the total cost.

ASEE has contracted with the International Cooperation Administration to carry out the project, estimated to cost $88,800. The Director of the team is Dr. William E. Stirton, Vice President of the University of Michigan, and Dean of its new Dearborn Center. The Deputy Director is Nathan W. Dougherty, Dean Emeritus of the University of Tennessee, and the secretary is Mr. Leslie Mayberry of Chicago, Illinois. Other members are:

Whitney C. Huntington, Professor Emeritus and former head of the Department of Civil Engineering at the University of Illinois and consultant for Harland Bartholomew and Associates.

Deane G. Carter, Professor Emeritus of Agricultural Engineering at the University of Illinois and for three years Coordinator of the International Cooperation Programs.

Royal W. Sorensen, Professor Emeritus and former head of the Department of Electrical Engineering at the California Institute of Technology and consulting engineer.

John C. Georgian, Professor of Mechanical Engineering, Washington University, who already has spent two years in India.

MISSION TO RUSSIA

Eight American engineering professors visited Russia in November and December in the first critical post-war study of the U.S.S.R.'s facilities for the education of engineers. The mission was a project of ASEE in cooperation with the East-West Contacts Staff of the State Depart-

ment, and was made possible by a $29,000 grant from the National Science Foundation.

Plans called for visits to schools and officials in Kharkov, Stalinsk, Tomsk, Novosibirsk, Frunze, and Moscow. The objective of the trip, which ended early in December, was the establishment of new viewpoints which may help American colleges and universities meet the Russian challenge in the field of scientific and engineering education. Since the general approach was to be similar to an ECPD inspection, the team was made up of individuals having extensive experience of that type or having a comprehensive knowledge of the Russian language.

Dr. Frederick C. Lindvall, chairman of the Division of Engineering at the California Institute of Technology and past president of ASEE, was chairman of the mission. Professor Newman A. Hall, Head of the Department of Mechanical Engineering at Yale University, was secretary. Other members were:

William T. Alexander, Dean of Engineering at Northeastern University, Boston, Mass., and President of ASEE,

Dr. William L. Everitt, Dean of Engineering at the University of Illinois, President of ECPD, and past president of ASEE,

Professor Ralph E. Fadum, Head of the Department of Civil Engineering at North Carolina State College,

Dr. Albert G. Guy, Professor of Metallurgical Engineering at Purdue University,

Dr. Ralph A. Morgen, Director of the Purdue Research Foundation, and

Dr. Leon A. Trilling, Associate Professor of Aeronautical Engineering at the Massachusetts Institute of Technology.

Members left New York for Copenhagen November 1 and entered Russia November 11. Their plans called for visits to at least 20 schools and educational organizations. At each school the mission planned to visit administrators and teachers, observe classes and laboratory facilities, study research activities, and collect syllabi, textbooks, and other material not now available in the United States. A report from this group follows on the next page.

NEW ENGINEERING BUILDING AT NYU

Ground was broken in November for the new Gould Hall of Technology at New York University's Bronx campus. Completion of the $2,000,000 engineering and technology building is anticipated by the early summer of 1960.

Participating in the groundbreaking ceremony was Mrs. Florence Gould, widow of the late Frank Jay Gould. Mr. Gould, an alumnus and an outstanding benefactor of the University, gave the money for the building prior to his death in 1956.

Gould Hall of Technology will be a four-story and lower-level structure standing on the west side of the campus. Its multi-purpose facilities will include instructional laboratories that also can be used for small lecture classes and general-use seminar rooms equipped for slide and film projection and television.

The exterior of the building will feature stonework corresponding with that in the Hall of Fame for Great Americans, which also is located on the campus.

Preliminary Report of the

ASEE MISSION TO RUSSIA

Engineering education of sound quality is effectively integrated into the planned economy of the U.S.S.R. This was one of the major observations of the eight man mission of U. S. engineering educators who returned in December from a three weeks study in the U.S.S.R. Among their observations were the dynamic character, the continuous process of re-evaluation, and the ability of such a controlled system to adjust to the inevitable variations in the capabilities at both the student and faculty level.

The mission was sponsored by ASEE and the National Science Foundation with the cooperation of the Engineers' Council for Professional Development.

This mission was initiated by the Department of State under an agreement with the U.S.S.R. for the exchange of scientific and cultural delegations. A comparable Soviet educational mission is expected to visit the United States in February 1959.

Members of the U. S. delegation visited twenty-five teaching and research institutions in Moscow, Leningrad, Kuibyshev and Frunze. The last is the capital of the Kirgiz Soviet Socialist Republic, situated on the border of China some 2,100 miles southeast of Moscow. Frunze was of particular interest because its engineering school is new, growing rapidly, and planned to meet the particular needs of an expanding industrial and agricultural economy.

The whole economy of the U.S.S.R. is integrated into a broad plan administered by an agency known as GOSPLAN. The formulation of the portion of the master plan related to engineering education is the responsibility of the Ministry of Higher Education.

A long range plan covering a period

ASEE Russian Mission members, left to right: front row—Dean William L. Everitt of Illinois, Prof. Newman A. Hall of Yale, Prof. F. C. Lindvall of Cal. Tech., and Dean William T. Alexander of Northeastern; back row—Prof. Ralph E. Fadum of North Carolina State, Director Ralph A. Morgen of Purdue Research Institute, Prof. Leon Trilling of M.I.T. and Prof. Albert G. Guy of Purdue.

normally of five years (currently seven years) is formulated first. Each year this master plan is modified to take into account the accomplishments actually achieved in the previous year. The plan considers the needs of the whole Soviet Union in the light of:

a) the expansion of industrial plant capacity,
b) the need for replacements,
c) the replacement by professional people of non-professional personnel not adequately trained.

The seven year plan now being formulated contemplates that an average of 350,000 graduates in all professional fields (engineering, science, medicine, languages, etc.) will complete their training each year. This is an increase of 40% over the average of the past seven years, but in engineering it is proposed that the increase shall be 90%.

The master plan specifies:

a) the number who may enter the institutions of higher education,
b) the number who may train for each field of specialization,
c) the quota of each specific institution for each specialty,
d) the jobs which will be available at the time of graduation.

Such planning demands that each student (at present upon graduation from the ten year school at the age of 17 or 18) must choose irrevocably a narrow field of specialization when he applies for admission to college. Alternatively, he may postpone this decision by entering industry and, under changes now contemplated, this period of industrial experience may become obligatory. The rules allow the student to apply for only one field of specialization in one institute in a given year. Furthermore, he commits himself to work in the particular phase of industry for which the course is designed. If he fails to secure admission in a severe competition (but one which varies in its severity with the field and institution), he may not apply for higher education for another year.

While the student makes a commitment as to his field, the goals and objectives of the plan may be changed by the State from time to time. Thus, specific curricula at certain schools may be eliminated. The students then enrolled in such curricula will be shifted to a similar specialty in which additional manpower is needed.

As indicated above, changes in the program are now under consideration. These include:

a) revision of the amount of industrial practice required,
b) broadening of the base of some curricula,
c) changing the number of students in specialties to fit the revised industrial program.

Since Soviet engineering education is planned to fulfil the specific needs of the State it is tailored in considerable detail to the jobs to which the young engineer will go upon graduation. The curricula are narrowly specialized in their objectives and prepare the students to be immediately useful to industry with a minimum of additional training. This results in dividing engineering into some 160 separate specialties such as mechanical engineer-automobile designer or mechanical engineer-automobile maintenance. This contrasts sharply with less than 20 fields accredited in the U. S., of which the great majority of students are included in about five fields.

The duration of the full-time day program is five or five and one half years. The first two years are broadly based on mathematics and science. But from the day of his matriculation the student pursues a specialty. For

the most part he meets, in lectures or laboratories, only with other students taking the same program. The illustrations in mathematics, physics, chemistry, mechanics etc., are selected to emphasize their application to his field. The last three years consist of increasingly specific courses, often built around design projects, industrial practice, and an elaborate diploma project requiring one semester of full time work. These projects involve extensive detailed drawing and are intended to acquaint the student both with principles and prevailing practice in his specialty.

The young Soviet engineers are well grounded and their best men are as good as any in the world. However, it appears to the delegation that many must be limited in their outlook by knowing little engineering outside their own narrow field.

Nowhere is the engineer and scientist held in higher regard than in the U.S.S.R. Engineering students and practicing engineers are exempt from military service. Indeed, engineers and scientists are among the aristocracy of Soviet society. There is, therefore, strong motivation and social pressure to aspire to such careers.

An engineering education opens the door to positions of high rank. On the other hand, to achieve such positions without some type of diploma would appear virtually impossible. In general, the limit of achievement of the non-graduate in an industrial enterprise is the position of foreman, while this is considered the minimum position for a graduate.

A motivation factor not to be underestimated is the strong devotion to a system that greatly encourages education. Those who qualify for admission to an institution of higher learning need not be concerned because of a lack of financial resources. Grants are provided by the State in sufficient amount to care for basic needs.

A system that offers such unique advantages to the educated instills a strong desire for higher education in the youth of both sexes. Currently about one-third of the total enrollment in the schools of engineering technology is comprised of girls. Competition for admission is keen. The planned economy provides one opportunity for every three to nine applicants, depending on the prestige of the institution and the importance attached to the specialty. Since students may make only one application for admission in a given year, the less able are motivated to apply for admission to a specialty in which there is a minimum of competition, rather than to the specialty of their first choice.

As a result of these factors a seriousness of purpose pervades the class room and laboratory. This is clearly evident to the most casual observer. The students themselves have a genuine respect for intellectual achievement and disdain for the laggard. For example we saw cartoons on bulletin boards drawn by students to scold those who do poorly in their work. We also saw a statue of a student studying his lesson on the way to class and were told that poor students are hazed by their fellows before this symbol. In this atmosphere approximately 90% of those who gain admission to the day schools complete diploma requirements and 50% of those in evening and correspondence programs graduate.

It was also observed that the educational system is able to adapt itself not only to changing industrial needs but also to the wide ranges in human interest and ability. The system recognizes the tendency of the most able people in intellectual fields to make their best contributions when asso-

ciated with others of comparable attainment and in an environment quite largely of their own choosing. It was observed that able people in the U.S.S.R. prefer to work in the larger cities and the older institutions, where cultural and intellectual activities are most widely available. Hence, the strongest faculties were found to be associated with educational institutions in these centres. While the detailed program for a given specialization is the same for a large number of institutions offering a given specialization, the Ministry of Higher Education recognizes that the level at which these topics will be taught must depend upon the background and ability of the professors.

Some fourteen outstanding institutions offer more advanced and individualized curricula. These institutions are given greater freedom in changing their curricula from the prescribed pattern. Modifications of appreciable magnitude are usually approved by the Ministry with little delay. These institutions as well as the stronger industrial groups and research institutes are expected to provide leadership in changing programs to meet new scientific and engineering developments. It also appears that competition to enter these institutions is keener and they attract the most able students from all over the Soviet Union.

For several years there has been much expressed difference of opinion in the U.S. concerning the quality of technological education in the U.S.S.R. This mission has had the opportunity to observe classes in operation, talk with teachers and examine curricula. It is clearly evident that thorough, scientifically based programs of study are in operation.

Laboratory equipment is of good quality and in ample supply but varies appreciably between institutions. In addition, considerable imagination has been used in developing equipment to demonstrate basic principles. Textbooks appear to be in ample supply and carefully prepared. They are encyclopedic in nature and include much practical information in addition to the theory. Furthermore, an extensive background in mathematics is required to follow accurately much of the text material. It appears that the entering student knows as much mathematics and somewhat more physics and chemistry than college freshmen entering the better engineering schools in the U. S. A. The Soviet 5 and 5½ year curricula afford time to give a good theoretical background in addition to much practice with problems specifically related to the student's specialty. However, it is believed that engineering education in the U.S.S.R. cannot be compared realisticaly with that in the United States because it is tailored to quite a different system.

The delegation was accorded every courtesy by the Ministry of Higher Education and by the faculties of the institutions that were visited. Competent interpreters were made available, who also became friends we would like to see again. Transportation facilities were on hand whenever needed—from Leningrad to Frunze, a range of 2,500 miles.

A genuine spirit of friendliness prevailed in the discussions of educational matters, which were free and uninhibited. Much interest in developments in U.S. education was manifested and a strong desire was indicated for participation in exchange missions to the U.S. We look forward with pleasure to the visit of the U.S.S.R. delegation.

THE BEST IS NONE TOO GOOD

LEE A. DuBRIDGE

President, California Institute of Technology

Address given at the Conference on Engineering and Scientific Education on November 1, 1957, Edgewater Beach Hotel, Chicago, Illinois. Others have made the principal points in this address, but few have made them more clearly or supported them so well with facts and figures.

In this Conference on Engineering and Scientific Education we have recognized a few basic and undeniable facts: (1) as any society becomes more technologically complex it requires that an ever larger fraction of its working force shall have technical training; (2) these technically trained people—the scientists and engineers—are indispensable to any modern society; they are, in fact, the creators of our society; they are indeed the "foundation of its strength"; and (3) unless such men and women are first *found* and then *educated*, we will not have them—and an important element of our strength will be missing.

And so today our attention has been focused in a most illuminating way just at the heart of the problem—how do we best find and educate the growing number of scientists and engineers that our society will need in order to build sound foundations of strength for the future? For it is now evident that we can no longer "trust to luck" that an adequate number of qualified technical men will somehow appear. We must evolve a national program to insure the supply.

Now I suppose the problems of higher education generally—and the education of scientists and engineers in particular—can be summed up in four questions:

1. How *many* shall we educate?
2. How *well* shall we educate them?
3. How much will it cost?
4. Where do we get the money?

Unfortunately, these four questions are not unrelated. The *number* we can educate is *not* independent of the *quality* of education we give, and both will be critically affected by the *funds* made available. Also, to a large extent, funds will come only in response to proved *needs* and proved *achievement*. Hence we must, in seeking new funds, be prepared to answer clearly the first two questions, which I shall refer to as the questions of quantity and of quality.

As to Quantity

The quantitative side of higher education has received great attention. It deserves to! The quantitative problem is terribly important. There is just no question about the fact that the American people are determined to see to it that not less than 30 per cent of their children enter college, and the chances are better than even that in 10 years, more or less, the goal will be approaching 50 per cent. In some of the more prosperous states 50 per cent of the high school graduates *now* enter college. (The figure was 59 per cent in California this year—thanks in large measure to our junior college system.)

Now, since all the children who will reach the age of 17 years during the next 17 years have already been born, we can easily count them and thus find out how many potential college entrants there will be each year. This has been done—and the figures are pretty staggering. The number of 17-

year-olds who could potentially be applicants for admission to our institutions of higher education was 2,300,000 in 1956, and will be 3,900,000 in 1972, an increase of 70 per cent. If, in addition, the fraction of these who enroll in college continues to increase as in the past, we would have more than doubled enrollments by that year.

In other words, if our present great educational system of 1800 junior colleges, colleges and universities is just adequate for present enrollments (and I hear little complaint about space going to waste!) then we are going to have to build the equivalent of 1,800 more colleges by 1972. We must double in 15 years the plant that has taken 300 years to build! We won't actually double the plant, of course, for many schools can double enrollment with possibly only a 30 to 60 per cent increase in plant size. But, in any case, the task is staggering; it will cost for physical facilities alone at least 10 billion dollars, possibly 15 billion, by 1972—say a billion dollars a year in capital funds.

We now spend 3 billion dollars a year in operating our universities and colleges—an average of about $1,000 per student (much higher, of course, in engineering). It is unlikely that the cost will go down; in fact, to bring faculty salaries to where they should be it must go sharply *up*. Thus we should add a billion dollars a year immediately to the budget, and by 1972, even if we are then spending only $1400 per student, we will need 8 billion dollars a year for higher education—in addition to the billion a year needed for plant additions.

As President de Kiewiet of the University of Rochester recently remarked in a brilliant paper on the subject, "All this is absurdly too much." *"Or,"* he adds, *"is it?"* He goes on to point out that American industry is spending at the rate of 25 billion dollars a year for new plant facilities. (Southern California alone is spending a billion dollars a year for new industrial plant.) American Telephone and Telegraph spent a billion dollars last year on new telephone equipment. If we can spend that much on helping people talk to each other, might we not spend an equal amount in helping them have something to talk about? There are at least a half dozen U. S. corporations that each have annual gross sales of over 3 billion dollars a year. Furthermore, 3 billion dollars a year is only 75 cents out of each hundred dollars of Gross National Product. In 1972, 8 billion dollars will be only $1.30 out of each $100 of projected GNP for that year. I cannot believe that will bankrupt us!

The bill has got to be met. The American people have decided to have more children and will not tolerate having half of their qualified youngsters refused admission to college. The only question is: When shall we pay, and how? Shall we meet the bill soon enough—or too late? Shall we meet it by private gifts or by taxes, or by how much of each?

So much for the quantitative side—a staggering job to be done at a staggering price, but a quite manageable job for the American people.

Let me add one more point. It is not the universities that are begging for all this money for their own aggrandizement. Most universities would prefer to stay at their present size—and just turn away an ever larger fraction of the less-than-brilliant applicants. It is up to the American people to decide whether they want this solution or not. If not, they must pay the bill.

As to Quality

But the quantitative problem is not the most serious one. Americans can scrape up an additional 3 or 4 billion dollars a year by 1972 if they have to,

and want to. Much more difficult—and more important—than the question of how *many* students are to be educated is the question of what quality shall the education be.

Unfortunately, in speaking of quality the problems cannot be stated in numbers. We can perfectly easily determine that one university is producing 5,000 graduates a year and another only 500. But there is no way on earth of measuring *in numbers* which group of graduates has had the better education.

There are, of course, ways of determining that a larger fraction of the graduates of University A appear in *Who's Who* than of University B. But is this because A attracts brighter students in the first place, or because it really gives a better education to comparable students? Or do most of B's students become farmers and not get listed in *Who's Who*?

We can learn too that the faculty members of University A publish more papers than do the faculty members of University B. But are they better papers? And does the faculty also do a better job of education? How shall we tell?

All this does not mean we can dismiss the quality problem. Quite the opposite! It means we must take off our coats and go to work and examine with great care the things we should expect our universities to be doing for each different type of student. For the fact is that though quality is difficult to express in numbers it is, nevertheless, a most conspicuous feature of higher education. Any well informed person knows perfectly well which are the finest educational institutions of the country.

Fortunately, the quality of education in science and engineering can be judged more satisfactorily than can higher education as a whole. Not that quality judgment for higher education is impossible, or for technical education is easy. But there are quality criteria in technical education for which we can find moderately good measures.

The conclusive test of what the quality of an educational institution *has been* is, of course, the quality of the alumni. If the alumni of 25 years ago appear to have attained, in relatively substantial numbers, positions of high achievement in science and engineering, and if they occupy posts of responsibility in government, in industry and in universities, we can then surely conclude that *25 years ago* that institution was doing a fine educational job—or, at least, it was attracting exceptionally able students.

If we seek to evaluate the institution of 5 years ago, we are on less sure ground, for the alumnus of 5 years back has not yet had time to prove himself—some may indeed still be in graduate school. We can still learn much about the quality of these alumni, however, even though we can be less certain of our conclusions.

In any case, a long history of alumni success is the earmark of the great institution. And since greatness has tremendous inertia—i.e., it is difficult to achieve but, once established, has a tremendous tendency to persist—we are usually safe in taking past performance, if consistently maintained, as a good measure of present quality or the lack of it. We must, however, always be on the lookout for the rising young institution.

Now if the measure of past achievement in a given field is the success of the alumni, then we must ask what are the sources of this success? What factors make for continuing high quality? There are, I think, at least four:

1. quality of students,
2. quality of faculty,
3. quality of leadership,
4. quality of teaching and research facilities. Each of these factors is worth a brief discussion.

Students—The matter of student quality is not usually given adequate nor adequately candid attention. The blunt fact is that by any sort of test of intellectual ability ever given, the average quality of students at some institutions is very substantially higher than that found at others. In fact, the upper quartile of students at some colleges may hardly come up to the lower quartile at others.

Now I do not say this is bad; in fact, I believe it is good and should be encouraged. I believe top-grade students will get a better education if they are in a place where there is stiff competition. And less able students will also do better if they are not hopelessly outclassed by their colleagues.

It needs to be realized that in technical subjects—in subjects like mathematics and physics which require a high degree of quantitative imagination—the difference in performance between a top student and a mediocre student is really very great. It is far greater than the difference suggested by giving the one a grade of 99 per cent and the other 60 per cent, for example. It is not a ratio of 5 to 3, but a ratio of 5 to 1, or 10 to 1—or, occasionally, 100 to 1—that we are dealing with. Now I think you will agree that trying to accommodate in one class a spectrum of student achievement ranging over a ratio of 10 to 1 presents serious difficulties, to say the least. That means, for example, a problem assignment which takes 2 hours for the best student takes 20 hours for the least able student. So, if we compromise and let the slowest student off with 5 hours of work, the best student may not be challenged at all. How we attack this difficult problem is one of the prime questions of technical education.

There are some people who will say we need not worry about the outstanding student—he will take care of himself. And they will point to the Thomas Edisons and Charles Ketterings who had very little formal education at all. But I think this attitude is wrong—very wrong. The future creative leaders of our science and technology should have the most challenging opportunities to develop their capacities—intensively and early. You can point to certain great scientists and engineers who were self-taught—but I can point to many, many more who developed under the challenging and understanding encouragement of a great teacher—an Ernest Rutherford, a Niels Bohr, or a Robert Millikan, to name but three in my own field of physics. There are so many examples of a great scientist building up a school from which other great scientists have come, that we are forced to the conclusion that even if we admit that a few come through handsomely, even though neglected, we can substantially increase the yield of good technical people if we provide the stimulation, the encouragement and the practical help that a high-quality educational center can give. Maybe the most important function of a great center or a great teacher is just to attract the best students and let them stimulate each other. If so, that is a most significant contribution. Of this I am sure: No institution can be better than the quality of the students it attracts.

If, then, we have a problem both of increasing the number of students *and* improving quality in our educational system, what shall we do about student ability? Shall we, as enrollments tend to rise, simply tighten up the admissions policies of our engineering schools, cutting off, say, by 1972, the lower half or two-thirds of those who apply, and who would *now* be admitted—keeping numbers constant

and educating only those of ever higher intellectual capacity?

There are some who advocate this course—and advance in its favor perfectly sound arguments about the importance of quality versus quantity. Some advocate it as a way of saving money.

Nevertheless, this extreme measure will not be accepted by the American people who are determined to have ever greater, not less, educational opportunities for their children. Nor is this solution, I believe, either practical or desirable—for four reasons:

1. Our selecting and predicting techniques are not nearly good enough yet to refuse a technical education to half of those who desire it and are qualified by today's standards. We would be cutting off many who, because of poor schooling, poor home environment, or other reasons, have made a slow start but may still do reasonably well—possibly very well. At least they should have a chance, somewhere, to try. Individual opportunity must remain. Though we must try to improve our selection techniques, they will never be good enough.

2. We need technical people at a variety of levels and with a variety of skills. And not all the talents we need are necessarily reflected in high academic standing. The old adage that "the A students make the professors and the C students make the money" is no longer good statistics, but it still is more than occasionally true that students of low academic standing later attain fine records of achievement.

3. The quantitative shortage of scientists and engineers is sufficiently severe and sufficiently long-term that we should seek to recruit a larger rather than a smaller percentage of students into our engineering schools. The additional men of good ability who will thus be salvaged will pay for the increased "wastage" of those who do not survive. (Actually, those who fail or who transfer to other fields are not really "wasted" at all. A good year of physics and math—even if failed—can't possibly do a man any harm!)

4. Finally, there is no conclusive evidence that under proper conditions rising enrollment in a particular institution necessarily results in declining quality or in lesser opportunities for the gifted student.

What then do we do to keep broad educational opportunity and also to insure the quality of training we need? I would propose that we:

1. Expand facilities for technical training throughout the country, especially in public institutions, to provide space for the same or a slightly larger fraction of the total college-age population as now, and at the same time improve our selection and recruiting techniques to make sure we attract all men of talent but eliminate the loafers and incompetents.

2. Make more extensive use of the junior college as a means for providing the first two years at low cost for many students—thus delegating to those institutions some of the task of eliminating the unfit, and selecting the better ones for upper-division work elsewhere.

3. Give all students of outstanding ability, whenever and wherever they appear, special attention, special encouragement, special incentive to go on beyond the routine work of the classroom, encouraging them, when appropriate, to transfer to other institutions where more adequate facilities or competition will be found.

4. Encourage many technical schools to expand their facilities, but encourage a few such schools around the country in their efforts to select only

the most able students and provide them with a supremely challenging program. We have such schools now—and many of them are facing a difficult dilemma. Shall they expand enrollment and make their excellent facilities available to more students—even at some loss in quality—or shall they put all available resources into higher and higher quality opportunities for a carefully selected few? Or can some, in fact, expand and raise quality also? I would not presume to judge what the proper course is for any particular school—except my own. But I do suggest that those who do elect to give high-quality instruction to a select few be given encouragement and support—in spite of the fact that some segments of public opinion will brand such institutions as "undemocratic," a horrible distortion of the meaning of that word.

Our most challenging task, in any case, is to find funds—especially for the private institutions—both to expand facilities and to improve quality.

Faculty—Let us turn then from student quality to faculty quality. There is really nothing we can say to make this problem any easier. Good scholars are very scarce. You would think, in fact, they would command the highest salaries of anyone in the community. But, instead, their salaries have always been low and, in purchasing power, they have been getting relatively lower. Our colleges and universities are subsidized by their faculty members who, in the nation as a whole, forego a billion dollars a year in salary because they love to live in a university atmosphere. Now that is very fortunate for higher education—but the universities are courting disaster if they allow this contribution to continue. Opportunities more remunerating, and in some ways equally rewarding, are now available outside the universities for scientists and engineers—especially young ones not yet bitten with the university bug. The quality of our faculties will surely erode away if we do not find ways of keeping a very much larger fraction of these bright young men in the teaching profession. The seed corn of the future is such a valuable resource that we must promptly begin to adopt more realistic methods of conserving it. The second report of the President's Commission on Education Beyond the High School flatly recommends that average faculty salaries be doubled in the next five to ten years. It is about the most sensible suggestion I have heard.

To have first-class colleges we *must* have first-rate faculty, and there is just no room for further argument on that point. We'll either get first-class talent and pay for it—or we will have second-rate universities. Again the decision rests with the American people.

This is no easy task. To double the top salary levels of professors in the leading universities means bringing them from the present $10,000–$15,000 salary levels to $20,000–$30,000. However, $20,000 is the annual income on some $500,000 endowment, and $30,000 is the income on $750,000. A group of 100 professors, then, will require an endowment of $50,000,000 to $75,000,000. Not more than 15 private institutions in the nation have that much endowment to cover *all* expenses.

The Ford Foundation recently made munificent gifts totaling $250,000,000 to the accredited private colleges of the country—some 600 in number. This was about equal to one year's salary budget for these institutions. As an endowment, therefore, it provided about a 4 per cent salary increase. To *double* the sal-

aries in these same institutions would have taken an endowment gift of 6¼ *billion* dollars! Impossible? Well, at least we must admit it won't be easy and we ought to get to work.

Someone, of course, will promptly say that all this is irrelevant: "You can't buy brains." I have already said that money isn't everything; that many people stay in teaching because they love it.

As a matter of fact, the entire science and engineering profession suffers from a disease of low salaries—or at least unbalanced salaries. Recent writers have dismissed the whole shortage problem of scientists and engineers as nonexistent because salaries for engineers have not risen as rapidly as in other fields. The law of supply and demand, they said, will tell how big the shortage is. This thesis, of course, ignores the psychological fact that a trained engineer would rather be an engineer at $8,000 than a salesman at $15,000. Conversely, offering a $5,000 salesman a salary of $8,000 does not make an engineer out of him. In other words, professional people generally are not in direct competition with other workers; and hence, even though they are scarce, they have lagged behind the rest of the economy in average real earnings. Teachers, unfortunately—though especially scarce—have lagged most of all, because the born teacher simply cannot bring himself to go into other fields. But teachers must also eat; their families must eat; their children must be educated. We will greatly increase our chances of keeping many talented young people in university teaching if we pay them more reasonable salaries. When a young Ph.D. is offered a starting salary in industry greater than the salary his professor receives after 30 years' experience, he is likely to conclude that university career opportunities have unfortunate limitations!

Leadership—The third qualitative criterion in university education is that of leadership: the leadership of the faculty, of the deans and other administrative officers, of the president and the trustees. Someone must set up the ideals which an institution seeks to achieve—and then keep the helm firmly fixed in that direction.

In 1908 a great scientist and scientific leader named George Ellery Hale became a trustee of a private manual training school in Pasadena, California. He persuaded the other trustees that southern California needed a technical university "second to none" in the nation. Fortunately, he wasn't laughed at, and within two years Troop Polytechnic School had transferred to other schools its 600 elementary and high school students, had retained its best 30 college students, moved them to a new campus and established a policy and a program which led straight to the California Institute of Technology of today. Leadership with vision and with determination brought to reality what in 1908 must have seemed to many to be a hollow boast or an empty dream. A similar story has been repeated at many institutions. Inspired leadership will attract inspired faculty; they will attract first-class students; and all together they will attract the necessary funds to make first-class institutions.

I cannot tell you how to manufacture inspired leadership among the trustees, faculty and administration of our technical colleges. I can only say that without it, new goals of high quality cannot be attained.

It has been said of Dr. Wickliffe Rose, onetime head of the General Education Board, that his insistent policy in supporting higher education was expressed in a single phrase:

"Make the peaks higher." Where he found inspired leadership—in administration or faculty—he advocated supporting it to the limit. Where superb quality was being achieved, he wanted to make it still better.

I believe higher education in America could well adopt Dr. Rose's motto, "Makes the peaks higher." This does not prevent making the base broader too—in fact, it requires it. But it brings out the fact that a major function of a broader base is not to take up more space, but to support the higher peaks.

There is no use denying the fact that such a policy is quite contrary to the views held by many educators. There are many who, in fact, advocate the contrary thesis: "leave the peaks alone and fill up the valleys." Their thesis would be to help the weak or so-called "needy" institutions rather than the best ones. This, it is claimed, is "the democratic way."

No one would deny for a moment that it is to the national interest to have many good universities, and that it is desirable for every college and university to get a little better. But it is equally important that there be a few institutions—we dare not hope for more than a few—of really superb quality. We must, for the sake of future generations, have a few outstanding leaders, a few institutions who are blazing the trails of the future.

Facilities—The last criterion of quality achievement can be briefly treated. A good institution needs adequate facilities. A good faculty needs adequate material support. "Mark Hopkins on one end of a log and a student on the other" is a fine ideal. But, as a New York State Court, passing on the taxability of student and faculty residences, once remarked: "Institutions early learned that a student must live somewhere else than on the end of a log. Nor is the other end a suitable residence for the teacher—particularly in northern New York (State)." Bricks and mortar are often despised as providing a substitute for scholarship. And one must admit that a great stone monument may house a mausoleum as often as a university. But bricks and mortar, steel and concrete, are essential elements in a fine technical institution. We must have laboratories for teaching and research; libraries where the knowledge of the past is readily accessible to the present; living and dining and recreation facilities conducive to a life of scholarship—these things are essential to students and faculty alike.

Hardheaded businessmen are inclined to criticize universities for making such "inefficient use" of space. A classroom, they say, is used only 6 hours a day, 5 days a week, only 9 months a year. Why not 70 hours a week instead of 30? Why not 12 months a year?

Well, why do we use the bedrooms in our houses only 6 to 8 hours a day? Why not take turns sleeping and make one bedroom do the work of three? Also, why do automobile assembly lines operate only 40 hours a week—with 6 weeks off every fall to change models?

The answer is, of course, that machines are made for men— not men for machines. Buildings and laboratories are designed to make learning easier, not harder. The time and efforts of people—of students, of faculty, of other employees—is far more valuable than the building space they need. It is poor economy to impede the work of a $20,000 professor (in 1965, that is!) for many years for lack of a few thousand dollars' worth of space. The entire capital cost of a university plant is often no more than 3 to 5 times the operating expenses for a year. And even if class-

rooms can stand being used 12 months a year, neither the teacher nor the student can. I do not defend real inefficient use of facilities where it exists—but in our technical colleges such inefficiency is rare. The lights burn late, summer and winter, in most engineering colleges I have seen. In fact, practically every major college of engineering I know has outgrown its plant. We must now make urgent pleas to foundations, individuals and corporations to give more generous consideration to providing adequate physical plant to institutions which have demonstrated high-class performance.

Finally, may I say again why our insistence on quality is so important? There has grown up an impression in certain quarters that industry and government—and even universities—have become so absorbed in numbers that they have forgotten quality. There is, in fact, a danger that the concern about numbers has given the public the impression that engineers can be counted up just like ditch diggers: to dig twice as many ditches, just hire twice as many diggers.

Now you and I know that nothing could be further from the truth. And it's time we told the truth more emphatically. Everyone here knows that the really sweeping new ideas in science and engineering have come from a very small number of brains. In any company, in any laboratory, the number of real technical advances is determined not by the total number on the staff, but by the number of unusually competent creative minds among them. I said previously that the country needs technical people at all levels—which is true because second-level men are needed to back up the top ones; third-level to back up the second-level; and many competent draftsmen, designers and technicians to convert ideas into usable hardware. But the *pace* of the whole effort is set by those at the top level—intellectually speaking. The major new ideas of the next decade will come from a dozen minds; the major advances in putting those ideas to work will come from a few hundred exceptionally able and well-trained scientists and engineers. If we can double *that* number, then we will have surely accelerated the rate of progress. But if we double only at the bottom and not at the top, then we may indeed doubt whether the effort is worthwhile.

We must make everyone in the nation aware of the fact that education is the foundation of national strength; that in building an adequate educational system we must aim always to "build the peaks higher"—for it will always be true indeed that the best is none too good.

"MICHIGAN GETS NEW FLUID ENGINEERING LAB"

TEACHING POSITIONS AVAILABLE

ASSISTANT OR ASSOCIATE PROfessor—to teach undergraduate and graduate courses in electronics and control fields. Teaching and research experience desirable. Salary and rank dependent upon degree and experience. Position now available. Inquire M. G. Northrop, Head, Department of Electrical Engineering, University of Louisville, Louisville, Kentucky.

MECHANICAL ENGINEERING DEpartment needs additional staff for Thermodynamics, heat transfer, metallurgy and machine design, M.S., Ph.D. or equivalent required. Interest in research desirable. Rank and salary dependent upon training and experience. Apply, Head, Mechanical Engineering Department, Louisiana State University, Baton Rouge, Louisiana.

TEACHING POSITION IN ELECtrical Engineering. Machinery and other undergraduate courses plus some graduate subjects at night. M.S. or Ph.D. preferred. Rank and salary depend on qualifications. Twelve-month appointment effective June or September, 1959. Address: Head, Electrical Engineering Dept., The University of Akron, Akron 4, Ohio.

PROFESSORS OR ASSOCIATES IN Civil, Electrical and Mechanical. Ph.D. required. Eleven months contracts. Resume to Dean Engineering, University of Santa Clara, Santa Clara, California.

FACULTY POSITIONS—ASSISTANT Professor positions open for persons with Ph.D. degree or equivalent in solid-state electronics, computers, networks, control, microwaves, and others. Part-time Teaching Associate positions also available for persons with M.S. degree or equivalent industrial experience who wish to work for the Ph.D. degree. Research and Teaching Assistantships available for other graduate students. Write to Chairman, Department of Electrical Engineering, University of California, Berkeley 4, California.

PROFESSORIAL APPOINTMENTS, each combining half teaching half research. Expanding activity has created positions for four Ph.D.'s with superior analytical and experimental ability. Among appropriate fields of interest are: electromagnetic theory and devices, electronics, dynamics and servosystems, aircraft structures, thermodynamics, hydrodynamics and fluid machinery, soil mechanics, physical metallurgy. Write D. C. Drucker, Chairman, Division of Engineering, Brown University, Providence 12, Rhode Island.

SMITH ACTING PRESIDENT AT CASE

College Notes

Kent H. Smith, board chairman of the Lubrizol Corporation and a member of the Case board of trustees, has been named Acting President of Case Institute of Technology, Frederick C. Crawford, chairman of the Case trustees, announced in August. Smith will serve until the return of Case President T. Keith Glennan, who is on leave of absence as the head of the National Aeronautics and Space Administration in Washington.

AN ESTIMATE OF GRADUATE ENGINEERS AND ENGINEERING JOBS, 1950-1965

HENRY H. ARMSBY

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Presented at the June, 1958, Annual ASEE Meeting in Berkeley.

An earlier estimate [1] combined National Science Foundation projections [2] of available engineering jobs with U. S. Office of Education projections [3] of engineering bachelor degrees to form a basis for forecasting the relationship between supply of and demand for engineers over the near future. Allowance was made for deaths and retirements, and for the same number of persons entering the profession without degrees as did so between 1940 and 1950. The estimate indicated an average net deficit of about 9,000 to 10,000 per year over the period 1955 to 1965.

This estimate uses the same projections of engineering jobs and engineering bachelor's degrees, but a slightly different approach. It attempts to indicate what fraction of the available jobs can be expected to be filled by graduate engineers—leaving as an open question the source of persons to fill the balance—if they are filled.

Table I presents estimates by the National Science Foundation [2] of the number of available engineering jobs for the years 1955 and 1960, and for the year 1965 a direct interpolation between the Foundation's estimates for 1960 and 1970.

The figures in Table I are estimates of the total number of "engineering jobs" which will be available for the various years if the total labor force of the country contains the number of people estimated by the Department of Labor and if the ratio of engineering jobs to total employment continues to increase in about the same ratio that it has been increasing over the past 50 years—approximately 30 per cent every ten years.

These "engineering jobs" are of three kinds: (1) jobs which clearly require persons of the ability represented by a college degree in engineering or its equivalent, (2) jobs which can be filled by persons with lesser educational qualifications such as technical institute graduates, and (3) intermediate. No exact figures are available as to what the relative sizes of these groups are or should be. However, it is highly probable that because of the steadily increasing complexity of industrial processes and the accompanying expansion in the applications of basic science, the proportion of jobs requiring college graduates for satisfactory performance will continue to increase.

Table II presents estimates of graduate engineers, "engineering jobs," and the ratios between them, for the three five-year periods shown. The various items are explained in the

[1] "An Estimate of Engineering Supply and Demand, 1955–1965," January 24, 1958, JOURNAL, May, 1958, pp. 715–718.

[2] "Trends in the Employment of Scientists and Engineers," NSF 56–11, May 1956.

[3] "Trends in Engineering Education—1939–40 to 1970–71, Revised January 24, 1958," prepared by Henry H. Armsby, U. S. Office of Education, JOURNAL, May, 1958, p. 716.

TABLE I

AVAILABLE ENGINEERING JOBS

	1955	1960	1965
Estimates of National Science Foundation, based on Total Labor Force, as projected by the U. S. Department of Labor	700,000	950,000	1,250,000

paragraphs following the table, which are numbered to agree with table items.

Table II also contains (in column 5) a similar analysis of figures for the decade 1940–50, which was made as a check on the general soundness of the method of analysis. The difference between item 8 in this column and item 2 in the column for 1950–55 is remarkably small (less than 4 per cent) for such estimates, and perhaps indicates that the method of analysis is reasonably sound.

TABLE II

ESTIMATES OF GRADUATE ENGINEERS AND ENGINEERING JOBS
(in thousands)

	Five-Year Period			Check on Decade 1940–50
	1950–55	1955–60	1960–65	
(1)	(2)	(3)	(4)	(5)
1. Engineering Jobs—Start of Period	534*	700	950	293*
2. B.S. Engineers—Start of Period	285*	417	526	178*
3. Ratio B. S. Eng'rs to Eng'g Jobs (2 ÷ 1)	53%	60%	55%	61%
4. New B.S. Engineers during Period	171	157	222	167
5. Entering Engineering (93% of item 4)	159	146	207	155
6. Total B.S. Eng'rs for Period (2 + 5)	444	563	733	333
7. Deaths and Retirements (1½% per year)	27	37	47	38
8. Net B.S. Eng'rs—End of Period (6 − 7)	417	526	686	295
9. Engineering Jobs—End of Period	700	950	1250	534*
10. Ratio B.S. Eng'rs to Eng'g Jobs (8 ÷ 9)	60%	55%	55%	55%

* U. S. Bureau of the Census.

EXPLANATION OF ITEMS IN TABLE II

1. *Engineering Jobs—Start of Period.* In columns (2) and (5) this is the number of persons classified as engineers in the U. S. Census report for the year. In columns (3) and (4) the figure is taken from Table I.

2. *B.S. Engineers—Start of Period.* In columns (2) and (5) this is the number of those in item 1 who had college degrees. In columns (3) and (4) the figure is brought forward from item 8 in the preceding column.

3. *Ratio of B.S. Engineers to Engineering Jobs.* As indicated, this is the ratio of item 2 to item 1. In other words, this is the percentage of engineering jobs for which graduate engineers were or will be available at the start of the period.

4. *New B.S. Engineers during Period.* This is the number of engineering bachelor's degrees granted or to be granted during the period, as shown in the source indicated by footnote [3] on page 1.

5. *Entering Engineering.* As indicated, this is 93 per cent of item 4. This is the fraction of the engineering graduating class of 1951 which a National Science Foundation study [4] found had entered the profession during the first year after graduation. Lacking any more recent figure, this ratio is used for the entire period of this estimate, although it may well be too low.

6. *Total B.S. Engineers for Period.* As indicated, this is the sum of items 2 and 5.

7. *Deaths and Retirements.* These are estimated at 1½ per cent per year [5] applied to the average number of B.S. engineers for the period—or 1½ per cent of the mean of items 2 and 6.

8. *Net B.S. Engineers—End of Period.* As indicated, this is the difference between items 6 and 7. It represents the number of engineering graduates available at the end of the period.

9. *Engineering Jobs, End of Period.* In columns (2), (3), and (4) this figure is taken from Table I. In column (5) it is the same as item 1 in column (2).

10. *Ratio of B.S. Engineers to Engineering Jobs.* As indicated, this is the ratio of item 8 to item 9. As in item 3, this is the percentage of jobs for which graduate engineers were or will be available at the end of the period.

Remarks

Such estimates as those in Tables I and II above involve many unknown factors, are subject to many possible errors, and can at best be considered only as approximations. For example, no allowance is made in these estimates for the graduate engineers who leave the profession, or for other people who enter the profession. These two factors will tend more or less to balance each other, but the exact ratios are unknown.

Officials of the Bureau of Labor Statistics point out that more accurate forecasts of engineering jobs could probably be made on an industry by industry basis. However, until this is done, the estimates of the National Science Foundation herein quoted are the best available, and their use results in a generally adequate picture of future needs for engineers.

The estimates of engineering degrees are based not merely on population and educational trends, but also on the assumption that those young people desiring an engineering education will be able to secure one. This implies that the engineering colleges can and will be able to provide facilities and staff capable of adequately serving a student body which is expected to increase by 85 per cent between 1955 and 1965 (135 per cent by 1970). It is to be hoped that this assumption is valid, but its realization will call for great efforts by all concerned—the colleges, the State and Federal Governments, and the public.

Even if these numbers of new engineers are realized, and especially if they are not, the national welfare demands that every possible effort be made to improve the quality of engineering education and the utilization of the engineers who are available.

The estimates of engineering degrees assume that engineering degrees will constitute a uniform percentage of total degrees issued. However, the estimates for total degrees assume a

[4] "Education and Employment Specialization in 1952 of June 1951 College Graduates"—National Science Foundation, 1955.

[5] Rate based on "Tables of Working Life for Men" of Bureau of Labor Statistics, U. S. Department of Labor.

continuation of the trend for an increase in the percentage of the age group which attends college. If this increase continues it raises a question as to the effect it will have on the general mental ability of the college population. In other words, it raises a question as to whether it will be possible for the engineering colleges to graduate the estimated numbers of engineers without lowering the general quality of these graduates.

The Bureau of the Census estimates [6] that between 1955 and 1965 the total population of the United States will increase by 15 per cent, those between the ages of 20 and 24 (roughly the college age) by 25 per cent, and those between 25 and 54 (the active productive labor force) by 4 per cent. These figures clearly indicate the need for increased productivity of the labor force, which must come from increased numbers of students pursuing higher education programs, and more importantly from improvements in the quality of such programs and from more effective utilization of their graduates.

The Bureau of Labor Statistics estimates [7] that during the same 10-year period total employment will increase by 17 per cent, non-agricultural employment by 23 per cent, and employment in positions classified as "professional, technical and kindred" by 43 per cent. By coincidence this last prediction agrees exactly with the projected increase in gross national product.

All the foregoing estimates are based on the "normal" growth of the country and on a continuation of the existing general political, economic, and social climate—with no major war or depression. A war would greatly expand the need for engineers—a major depression could seriously reduce it.

During recent months the country has experienced a minor reduction in industrial activity, and the "market" for engineers has "softened" in certain places and certain fields. However, this is in all likelihood a temporary condition, which can, and probably will, quickly change as the nation reacts to the challenge symbolized by Sputnik. In fact, there is some evidence at hand indicating that the "low point" in the demand for engineers has already been passed. All the basic trends in this country, such as population, productivity, gross national product, use of technology in industry, and others, are upwards for the long term, and one who tries to look ahead ten years can probably disregard such temporary "dips in the curve" as the current one.

Questions

The foregoing estimates and discussions lead directly to a number of questions of importance to the engineering profession and to the nation. No attempt is made here to answer them. They are merely presented for discussion.

Some of these questions relate to the fraction of total "engineering jobs" which need to be filled by graduate engineers, and how this fraction will change in the future. Others seek to find the sources of the "non-degree" engineers.

Questions are also suggested as to whether or not the young people who go to college are the ones who should go, and whether among those who do go to college the ones registering in engineering are those who ought to

[6] Current Population Reports, Population Estimates, Series P-25, No. 123 (October 1955) and No. 170 (December 1957).

[7] Address by Ewan Clague, Commissioner of Labor Statistics, before AFL–CIO Conference on Changing Character of American Industry, Washington, D. C., January 16, 1958.

do so. Such questions lead directly to others concerned with the need or desirability of an extensive system of scholarships, and a question as to how they should be awarded if there is to be such a system.

Another question raised by the estimates concerns the numbers of women who could and should be attracted into the engineering profession. At the present time the number of women graduates is less than one per cent of the number of men. This appears to offer possibilities for greatly increasing the numbers of well trained engineers coming out of our colleges.

FELLOWSHIPS IN HIGHER EDUCATION

The Center for the Study of Higher Education at the University of Michigan, Ann Arbor, Michigan, under a grant from the Carnegie Corporation of New York, will again have several fellowships in higher education for the academic year 1959–1960.

Five persons will be appointed as Michigan Fellows in College Administration. To qualify, the applicants must have completed their normal academic training, having the doctor's degree or equivalent, and have demonstrated outstanding promise for educational leadership. The stipends vary with individual needs but are intended to cover living expenses as a substitute for salary, subject to a maximum grant of $8,000. The Fellows for 1958–59 have included a young college president, two deans and two professors of history. Their activities illustrate the individualized possibilities for training that can be provided at the Center. All participate in a seminar on higher education; each takes or audits courses relating to college administration, or courses that broaden one's cultural background; three are pursuing research studies, one a plan for institutional self-evaluation; and four of the group are getting varied internship experiences, such as serving as part-time assistants to academic deans or vice-presidents. It is expected that by the end of the year, the Fellow will be ready to assume larger responsibilities in college or university administration, having an improved philosophical understanding of higher education and additional knowledge of the theory and practice of administration.

A few fellowships will also be available on a pre-doctoral basis. They are intended to assist students of high merit to pursue their study toward the doctor's degree, and to facilitate research in higher education at the Center. A year of graduate study of high quality (in any academic field) is a prerequisit. The stipends range from $500 to $3,000.

Applicants for either type of fellowship should be under 40 years of age. Applications should be submitted to the Director of the Center prior to February 1.

COMPILATION OF FACULTY EMPLOYMENT PROGRAMS SUMMER 1959

C. E. WORK

Michigan College of Mining and Technology
Houghton, Michigan

Sponsored by the Relations with Industry Division

Each summer there are a large number of opportunities for college faculty members to obtain employment in private industry or in government laboratories. This short-term employment does not interfere with their academic responsibilities or the continuity of their teaching programs. It does, however, give them a closer look at the kind of environment their students are to enter and keeps them abreast with the latest applications of their phase of technology in practice.

On the other hand, the professors frequently work on projects which, although important, yet keep being postponed by the permanent employees. Their contributions are made at a time when, because of vacations, the regular staffs are not at full strength. They offer fresh viewpoints on problems on which those with long intimate contact may have grown stale.

The contacts and acquaintances the professors gain in industry and that the industrial groups form with college personnel as a result of programs of summer faculty employment are of lasting mutual benefit.

The promotion of programs to utilize college teachers in industry during the summer months and to make known to faculty members what some of the opportunities available to them are for 1959 has been undertaken by the Relations with Industry Division of ASEE. In addition to including industrial members of ASEE, government agencies known to be active in summer employment of faculty members have been invited to submit information for publication this year.

With publication schedules requiring prediction in September what is to be done the following June, some changes of plans for summer employment programs can always be expected. Occasionally, rather drastic changes are required. 1958 turned out to be a year of limited budgets, forcing many companies to reduce or completely give up the programs of faculty employment they had planned for last summer. Several organizations were not far enough out of the slump in September to venture any predictions for 1959.

However, as the compilation shows, many companies expect to continue these activities in 1959. Those planned on a more or less formal basis are listed in Part I. These programs are intended to give the professor opportunities, beyond his individual job assignment, to gain a broad understanding of the company's philosophy and operations. The companies listed in Part II expect to hire college faculty members for summer work but their orientation within the organization is to be left mainly to the professor himself and his supervisor.

Part I. Formal Programs

Key to Symbols Used in Compilation, Columns 5–8

5. Other activities
   - U tours of facilities
   - V social and recreation
   - W luncheons etc. with company personnel

6. Basis for payment
   - S college salary rate
   - Q job assignment and qualifications
   - R honorarium or fixed stipend

7. Other allowances
   - T travel
   - F food
   - H housing
   - C cost of living

8. Individual Assignments
   - J job on company project
   - K study some phase of company's operation
   - L none

Company (Name and address)	*Contact* (Person and position)	1 Backgrounds included	2 Length, weeks	3 Number of participants	4 Number of seminars	5 Other activities	6 Basis for payment	7 Other allowances	8 Individual assignments
Allison Division General Motors Corp. Indianapolis 6, Ind.	R. C. Smith General Supervisor Salaried Personnel Dept.	Tech.	8–12	6–25	4	W	S	T	J
Boeing Airplane Co. Seattle, Wash. (Wichita, Kansas)	Stanley M. Little Employment Administrator	Tech.	9–12	50	8	U, V, W	S	T, H	J, K
California Research Corp. 200 Bush Street San Francisco 4, Calif.	D. P. Krotz Asst. to the President	Tech.	8–12	2–5	—	U	Q	T	J
Chance Vought Aircraft Dallas, Texas	P. B. Cobb College Relations Representative	Tech.	8†	20	10	U, V	Q	T	J
Continental Oil Co. P. O. Box 2197 Houston 1, Texas	Gerald F. Bassler Director Pers. Development, Industrial Relations Dept.	Tech, Non-Tech.	1–8	10	—	U, V, W	Q or R	T	J or K
Convair, Division of General Dynamics Corp. Fort Worth, Texas	H. A. Bodly Administrative Supervisor, Eng'g Dept.	Tech.	8–12	10–15	2–5	U, V	Q	T	J
Detroit Edison Co. 200 Second Avenue Detroit 26, Michigan	P. Amerman Director of Employment	Tech, Non-Tech.	8–12	5*	2	U, V, W	Q, S	T	J or K
Douglas Aircraft Co. Santa Monica, Calif.	C. C. La Vene Employment Manager, Engineering Division	Tech.	10†	30–35	—	U	Q	T	J
Hughes Aircraft Co. Culver City, California	Leonard C. Silvern, Asst. Hd., Office of Advanced Studies	Tech, Non-Tech.	12	150	22	U, V, W	S	T, F, H	J
Humble Oil and Refining Company Houston 1, Texas	R. N. Dyer, Head Personnel Division, Employee Relations Dept.	Tech, Non-Tech.	8–12	40–50	8	—	Q	T, H	J
International Business Machines Corp. 590 Madison Avenue New York 22, New York	R. E. Rodgers Manager, Technical Recruitment	Tech.	8–10	30–40	7	U, V, W	Q	T	J
Lockheed Aircraft Corp. Missile Systems Division Sunnyvale, California	T. E. Lyons, Supervisor Education and Training	Tech.	8–10	15–20	8–10	U, W	Q	—	J
McDonnell Aircraft Municipal Airport St. Louis 3, Missouri	C. J. O'Toole Asst. Employment Manager	Tech.	12†	20–25	1	U, W	S	C	J

* Only applicants from the area near the company's operation are considered for summer employment.
† In order to obtain clearance, early application is required.

PART I.—*Continued*

Company (Name and address)	*Contact* (Person and position)	1 Backgrounds included	2 Length, weeks	3 Number of participants	4 Number of seminars	5 Other activities	6 Basis for payment	7 Other allowances	8 Individual assignments
Minneapolis-Honeywell Regulator Company Minneapolis 8, Minnesota	A. Lachlan Reed Director, Industry-Education Relations	Tech.	8–14	5–20	5 to 10	U, W	S	T	J
Minnesota Mining & Manufacturing Co. Saint Paul 6, Minn.	Wendel W. Burton Employment Manager 900 Fauquier Ave.	Tech.	8–10	5–6	1	U, V, W	S	T	J
Pratt & Whitney Aircraft East Hartford, Conn.	Charles T. Baker Engineering Department	Tech.	8–12	20–30	6	U, V, W	S	T	J
Public Service Electric and Gas Co. 80 Park Place Newark 1, New Jersey	Herbert Wottrich Assistant to General Manager, Electric Department	Tech.	8–12	5	4	U, W	Q	—	J
Radio Corp. of America Camden 2, N. J.	Robert Haklish, Mgr. College Relations	Tech.	8–12	10–15	—	U	S	T	J
Sandia Corporation Sandia Base Albuquerque, N. M.	K. A. Smith, Manager Employment and Personnel Department	Tech.	12	25–35	—	U, W	Q	T	J
Standard Oil Co. (Ind.) Research Department Box 421 Whiting, Indiana	E. W. Adams Administrative Director, Whiting Laboratories	Tech.	8–12	5–6	3	U, V, W	Q	T	J
Sun Oil Company Research & Engineering Dept. Marcus Hook, Pa.	Robert A. Matteson Administrative Assistant	Tech.	8–12	2–5	4 to 6	U, V	Q	—	J
Thomas A. Edison Industries 51 Lakeside Ave., West Orange, N. J.	Donald W. Collier Vice President & Director of Research	Tech.	8–12	1	0	U, W	S	—	J
U. S. Army Chemical Corps Engineering Command Army Chemical Center, Md.	Roy W. Muth Commanding Officer	Tech.	8–18	10–15	—	U, V, W	Q	—	J
U. S. Navy Electronics Laboratory San Diego 52, Calif.	Sidney W. Sandburg Employment Superintendent	Tech.	4–14	5–12	6	U	Q	—	J
U. S. Naval Research Laboratory Washington 25, D. C.	C. N. Mason, Jr., Head, Employment Br., Personnel Div.	Tech.	8–12	10–15	—	U, V, W	Q	T	J
U. S. Steel Corp. 525 William Penn Place Pittsburgh 30, Pa.	C. D. Feight Director Employment	Tech.	9	10–20	9	U, V, W	S	T	J
Western Electric Co. 195 Broadway New York 7, New York	R. W. Reckhow Coordinator of College Relations	Tech.	8–12	10–20	3	U, W	Q	—	J
Westinghouse Electric Company East Pittsburgh, Pa.	R. Craig Fabian, Supv. University Relations, Education Dept.	Tech.	12–14	20–25	1	U, V, W	R	T, F, H	J

PART II. INFORMAL EMPLOYMENT

Company	Contact
Acme Steel Company * Chicago 27, Illinois	H. L. Bills, Vice-President and Director of Industrial Relations
Air Reduction Company 150 E. 42nd St., New York 17	F. R. Balcar, Coordinator Research and Engineering

* Only applicants from the area near the company's operations are considered for summer employment.

Company	Contact
Allis Chalmers Manufacturing Co. Box 512, Milwaukee 1, Wisconsin	Paul A. Bierwagen, Supv., Graduate Studies Graduate Training Section
Aluminum Company of America Pittsburgh 19, Pennsylvania	R. L. Gaughler Manager of College Recruitment
American Cyanamid Co. 30 Rockefeller Plaza New York 20, New York	Frank H. Hurley, Manager College Relations
American Viscose Corp. 1617 Pennsylvania Blvd. Philadelphia 3, Pa.	William M. Nolan Recruitment Manager
Bethlehem Steel Co. Bethlehem, Pennsylvania	A. M. Rupkey Manager of Personnel
Canadair, Limited P. O. Box 6087, Montreal, P. Q. Canada	A. C. Holden Engineering Services Supervisor
Caterpillar Tractor Company Peoria, Illinois	M. D. MacLean, Professional and Technical Employment
Chemstrand Corporation Decatur, Alabama	A. D. Preston Technical Personnel Manager
Chicago Bridge and Iron Co. 1305 W. 105th Street Chicago 43, Illinois	I. E. Boberg Vice President
The Cleveland Electric Illuminating Co. 55 Public Square Cleveland 1, Ohio	J. P. Fleming, General Supervisor Personnel Services Section
Continental Motors Corp. 8647 Lyndon Street Detroit 38, Michigan	Peter Altman Vice President
Corning Glass Works Corning, New York	L. W. Larson Director of Training
David Taylor Model Basin Washington 7, D. C.	S. Di Maria Employment Officer
Deere & Company Moline, Illinois	E. H. Case, College & Univ. Relations
Eastman Kodak Company 343 State Street Rochester 4, New York	J. H. Howard, Director Business and Technical Personnel
Erie Resistor Corp. Erie 6, Pennsylvania	Robert W. Sparks, Supervisor of Placement and Training
Esso Research and Engineering Company P. O. Box 175 Linden, New Jersey	Charles W. Smith, Director Employee Relations
Food Machinery & Chemical Corp. Chemical Division 161 E. 42nd St., New York 17, N. Y.	A. J. St. Louis Recruitment Manager
General Electric Company Schenectady, New York (and others)	W. Scott Hill Manager, Recruiting Engrg. Personnel Dept.

Company	Contact
Goodyear Tire & Rubber Co. Akron 16, Ohio	W. F. Catron, College Relations Technical Personnel
International Harvester Co. 180 North Michigan Avenue Chicago, Illinois	F. D. MacDonald, Chairman Manpower Committee Education & Personnel Department
International Paper Company Mobile 9, Alabama	Samuel W. Jenkins Southern Kraft Division
International Resistance Co. 401 North Broad Street Philadelphia 8, Pennsylvania	Walter J. Gershenfeld Personnel Manager Central Office
Johns-Manville Corporation 22 East 40th Street New York 16, N. Y.	Ledwith J. Brennan Director of Training
Marquardt Aircraft Company P. O. Box 2013, South Annex Van Nuys, California	J. T. Dale, Manager Professional Personnel
Monsanto Chemical Company St. Louis 24, Missouri	Robert F. McCoole Technical Personnel Manager
Northern Illinois Gas Company 615 Eastern Avenue Bellwood, Illinois	R. A. Lightbody Assistant Vice-President
Philadelphia Electric Co. 900 Sansom Street Philadelphia, Pa.	G. W. Kaufmann, Jr. Director, Employment Div.
Philco Corporation Philadelphia 34, Pennsylvania	Robert T. Love Coordinator, College Relations
Phillips Petroleum Company Bartlesville, Oklahoma	D. R. McKeithan, Director Technical Manpower Division
The Pure Oil Company 35 East Wacker Drive, Chicago, Ill	J. J. Stadtherr Training Director
Radio Corporation of America Camden 2, New Jersey	Charles R. Vennel, Jr. College Relations
Ramo-Wooldridge Corp. P. O. Box 45215 Airport Station Los Angeles 45, California	Donald L. Pyke, Head Technical Staff Placement
Raytheon Mfg. Co. 1360 Soldiers' Field Road Brighton 35, Mass. (and others)	John B. Whitla College Relations Administrator
Rohm & Haas Company Philadelphia, Pa.	Dr. J. S. Strong Office of Technical Employment 5000 Richmond Street
Scott Paper Company Chester, Pennsylvania	Richard B. Miller Manager of Corporate Employment
Shell Development Company Emeryville, California	Mott Souders Director, Oil Development
Stromberg-Carlson Co. a Division of General Dynamics Corporation Rochester, 3, New York	Fred E. Lee Manager of Technical Personnel

Company	Contact
Swift & Company Union Stock Yards Chicago 9, Illinois	E. D. Hall, Head Personnel Division Research Laboratories
Sylvania Electric Products, Inc. 1740 Broadway, New York 19, N. Y.	Harris Reinhardt Manager, Organization Development
Toledo Edison Company * Toledo, Ohio	Frank W. Keith, Director Employee Relations
U. S. Army Engineer Dist. P. O. Box 1027 Detroit, Michigan	W. L. Cooper Civilian Personnel Officer
U. S. Army Engineer School Fort Belvoir, Va.	J. D. Strong Director, Department of Non-Resident Instruction
U. S. Naval Ordnance Laboratory White Oak Silver Spring, Maryland	Michael A. Califono Employment Officer

* Only applicants from the area near the company's operations are considered for summer employment.

ENGINEERING SCIENCE DEPARTMENT AT DARTMOUTH

A new Department of Engineering Science was added to Dartmouth College's Science Division this past fall. It began operation with the introduction of a three-term, three-course program. The department will be staffed by members of the faculty of the Thayer School of Engineering under the chairmanship of Dean William P. Kimball. In cooperation with the Departments of Mathematics, Physics and Chemistry, it will offer a new four-year major in engineering science, beyond which the student may go on to a fifth year at Thayer School. It will also be the means of carrying out a new program designed to integrate engineering studies with the basic physical sciences in line with the demands of new technologies.

The new major provides a common core of academic work for all men pursuing engineering studies. At the end of the four-year program the student may terminate his course of study and graduate with the A.B. degree. Qualified men who want to acquire a professional engineering degree will take a fifth year at Thayer School, leading to the Bachelor of Science degree in civil, electrical, or mechanical engineering.

A further option for graduate work under the new program is a fifth year in engineering science. Restricted to the ablest students, this curriculum offers graduate courses in math, physics, and engineering theory and requires a Master's degree thesis. It leads to the Master of Science degree.

THE ROLE OF THE FEDERAL GOVERNMENT IN SUPPORTING BASIC ENGINEERING RESEARCH

GENE M. NORDBY

Formerly Program Director for Engineering Sciences, National Science Foundation, now Head, Department of Civil Engineering, University of Arizona, Tucson

Presented at the ECRC Session, at the Annual Meeting, Berkeley, June 18, 1958.

In the fiscal year 1957, the expenditures by the Federal Government for scientific research and development amounted to approximately $3 billion. The expenditures for the fiscal year which ended July 1, 1958, are even greater but as yet are untabulated. More than 60 cents of every dollar for conducting research and development was obligated for development; less than 40 cents for research, and of this 40 cents only 8 cents was for basic research. Subdividing the dollar another way, 48 cents was spent within the Federal Government, 35 cents went to profit institutions, and 14 cents went to educational institutions. This amounts to nearly one-half billion dollars for these activities in universities and colleges throughout the United States. One need not state more figures to illustrate the important role of the Federal Government in research activities in the schools represented by ASEE. Of course the role it plays is described by one word —MONEY!

More than two-thirds of the funds for research in educational institutions is provided by the Federal Government. This has been both a boon and a curse to these schools. Certainly many misunderstandings have arisen concerning the motivations of the Government and the methods of distributing this money. The cry of mistreatment has been particularly great by engineers. In this article the writer does not intend to "ride the fence" in dealing with these problems. There will be some critical remarks for both sides of the arguments. Perhaps at the end, neither the government nor schools will be reconciled with the other's viewpoint; however, maybe it will result in a better understanding and a better answer to our research problems.

Why Support Research

First, it would be well to review why the Federal Government is involved in the support of research. In sponsoring research and development through nonprofit institutions, Federal agencies may have either of two objectives in mind. They may be seeking scientific knowledge to assist them in carrying out the responsibilities with which they are charged. In this case they may be said to be "purchasing" research and development services. On the other hand, they may be seeking to add to the general fund of scientific knowledge as a matter of public interest. The distinction between the two types is important to the understanding of the nature of Federally-sponsored research work.

In the case of "purchased" research and development, emphasis must necessarily be placed on the ability of an institution to perform a specific task expeditiously and well, and

achieve results of direct value to the interested agency. Naturally, much of this research is now directed toward defense activities. This type of research may be placed in private industry, in educational institutions, or nonprofit research institutes or with any group most competent to do the job. On the other hand, in supporting research and development as an aid to science, account must be taken of other factors, such as the relation of the proposed work to the long-range progress of science, the development of research potential, the needs of geographical areas, as well as educational benefits when the research is placed at educational institutions.

This distinction is not always clear cut in institutions. It frequently happens that progress in science to which an institution is dedicated coincides in a given field with the justifiable interest of an agency, for eminently practical reasons. Thus, in a defense agency, for example, basic research in a particular field essential to development progress may justify support by the agency.

Mechanisms for Support

The mechanisms for supporting this research have been many. Conspicuous among post-war organizational developments for research activity has been the so-called "research center," administered usually by a single university or a group of universities, with support from the Federal Government. The research center developed as a pattern during World War II when a number of universities were engaged on research and development contracts for the Government through the Office of Scientific Research and Development. In several instances, the volume of work, coupled with its highly classified nature, made it advisable for the university to segregate its war research from its regular teaching and research functions and concentrate it in a separate laboratory. Typical of such laboratories were the Radiation Laboratory at M.I.T., the Applied Physics Laboratory at Johns Hopkins, the Underwater Sound Laboratory at Harvard and the Jet Propulsion Laboratory at the California Institute of Technology. Following the war some of these laboratories went out of existence and new ones were created as the military services and the Atomic Energy Commission continued to look to the universities for large-scale research and development work.

The establishment of Brookhaven National Laboratory on Long Island by Associated Universities, Inc., a group of nine eastern universities, marked the first time that a group of universities had incorporated for the purpose of carrying on research and development for the Government. Although its principal source of support is the Atomic Energy Commission, Brookhaven now carries on a wide variety of research projects, the majority of which are in the field of unclassified basic research, and it enjoys support from many different sources.

More recently Associated Universities, Inc., was chosen by the National Science Foundation as its contractor for a new Radio Astronomy Observatory to be established near Green Bank, West Virginia. In 1953, fifteen midwestern universities formed an association for the purpose of furthering research on high energy accelerators. This group is known as the Midwestern Universities Research Association. Newest of all groups is the Association of Universities for Research in Astronomy, which incorporated last fall for the purpose of establishing and operating the new National Astronomical Observatory.

It is important that this trend continue within reason because the magnitude of equipment and facilities required for modern research is often beyond the financial or operating capacity of a single university. This is a type of activity which engineers should study and in which they can show their unity by giving their support to certain important institutes. A typical institute might be sponsored by a group of universities and would offer opportunities to university scientists and graduate students, but it would be autonomous, standing separate from any single educational institution and planned to serve all institutions responsible for research in the scientific area in question. Thus, institutes might be established, for example, for solar energy research, materials research, or gas dynamics research. The impetus for such institutes should, however, grow out of the mutual interest by a group of scientists and be guided by national interests and not those of an individual scientist or institution alone.

Individual Projects

Despite the rise of research centers, the individual grant or contract to a University in the name of a qualified professor has been the main method of supporting basic research in recent years. I believe that the university scientist will continue to be the key individual of the Government contract or grant program in research regardless of the motivation of the agency concerned. It is his leadership which is needed in the conception of fresh, orginal ideas and in the exploration of new, fruitful fields in all scientific areas. After all it is the university environment and method of working which is conducive to this free-lance type of research. This is basically the reason why most agencies work by what is known as the proposal method. The proposal is the device by which the scientist submits his idea for evaluation. It contains the "seed" of an idea which may germinate into a "breakthrough" into new knowledge. In submitting these proposals the scientist should beware, therefore, of orienting his research thinking and experimental studies along "popular lines" because of the mistaken belief that these will most readily receive Government financial support. He should not be reluctant to submit imaginative suggestions for research support.

On this point Government research administrators oftentimes get into disagreements with engineers. Engineers are trained to find answers to specifically defined problems, but in this business we are asking them to define problems and then to solve them. Only by this procedure can we draw upon the imagination of the whole scientific population rather than the imagination of a few Government administrators. Consequently, it is urged that no attempt be made, in the submission of research prosposals, to "second-guess" Government administrators. The existence of different agencies with different motivations, different programs and interests, and different operating mechanisms will always provide a source of funds for worthwhile research ideas.

There are several agencies important to engineers which support research in the manner just described. The Office of Naval Research, the Air Force Office of Scientific Research, Office of Ordnance Research, the Atomic Energy Commission, and the National Science Foundation are the largest and most active of these. If you are a researcher or research administrator you should familiarize yourself with their policies. In fact, many of the active research schools find it advantageous to have a repre-

sentative call upon these agencies periodically for liaison purposes and to discuss their program.

You will note that the NSF enabling legislation restricts its support to "basic" research. You will also note in the ECRC *Survey*, that if "engineering administrators had their way" their activity would swing very strongly towards basic research (probably to 65 to 70 per cent of the total) and away from applied research. Despite the fact that many definitions of *basic* have been bandied about, no one is sure what the term means, and perhaps if Congress knew how much trouble it caused, maybe they would not have put it in the law in the first place. Other members of the physical sciences—well reinforced by the *traditionalists* in the engineering ranks—define engineering as an applied science and say it is not concerned with "basic" research. Of course if this is the case, the physical scientists have placed a "halo" around their heads and are merely protecting their own bailiwick, usually because of their lack of understanding of the present trends in the engineering sciences. Nevertheless the other faction of our opposition is of more vital concern to me because it will be difficult to win our battle for progress in engineering science research with a house divided.

Current Trends

Current trends in engineering education are toward emphasis of basic scientific knowledge and away from the traditional applied or "how to do it" courses. Graduate work in engineering at the M.S. level is becoming common, and the need for advanced work at the doctoral level for more engineers is becoming evident. Thus, a trend which was followed by the other physical sciences—physics, chemistry, and mathematics—many years ago is today appearing in engineering. This transition period is a difficult—yes, even painful one—for many. Let me present some facts to reinforce my arguments. The estimated total cost to the nation of research and development in the natural sciences and engineering in 1957 approached $10 billion, according to a recent NSF survey. Because of its growth and importance to the national economy, Professor Sumner Slichter, famed economist of Harvard University, has dubbed the research industry as our "industry of discovery."

Martin R. Gainsbrugh, Chief Economist of the National Industrial Conference Board, in a recent article stated that

> Within little more than a decade, investment in research has become a major form of capital outlay. More, in fact, was invested in research than in either new plant or new equipment in manufacturing. Over one-fourth of all natural scientists and engineers, about 230,000, were employed in research and development in 1954 with 400,000 supporting personnel.

There is little doubt that these figures may be greatly increased for the current period.

Certainly, the time has come to examine critically our educational system in engineering to see if we can provide more proper training for the work future engineers are going to do. Indeed, if discovery is going on at such a fast pace, the engineering designer must also get increased training in science to make faster use of these scientific advances as they are made. The engineer must assume the role of the interpreter of science to practice, an area in which this country is seriously lacking for the future. It seems to the writer that this situation may be improved by increased emphases on the engineering sciences and the research activity which naturally follows. At a recent research

and development conference in Washington, Dr. James Killian, Science Advisor to the President, stated, "We need more engineering research in our engineering schools not only because we need more research but because we need more engineers nurtured in the atmosphere of research."

Under this type of stimulus it is natural that the Government's research program is aimed at the future science emphasis in engineering. Thus the "basic" research in engineering sciences sponsored by the various agencies *is* in general areas such as electronics, electromagnetic fields and systems, fluid mechanics, heat transfer and thermodynamics, and mechanics of materials. While these researches are usually performed by workers whose designation is one of the conventional departments of engineering, the work is not limited by the boundaries of Civil, Chemical, Electrical, Mechanical or other engineering specialties but instead moves freely across these disciplines, both in its origin and contributions. Except for the inherent orientation derived from the "feed back" process of ideas for research flowing from practical problems they must solve, the research performed is often indistinguishable from that performed in the other physical sciences.

An example will aid in illustrating the type of thinking that is derived from such research. The area of materials research is a field common to all engineers.

Greater Complexity

Within the past two decades the problems in this field seem to have taken a more complex turn, due to the introduction of such developments as supersonic speeds, rocket-type operations that demand high-strength materials with light weight, materials to withstand extreme temperatures of combustion, and unusual materials to satisfy the unique requirements of nuclear reactors. In addition, more is now understood about high rates of strain, and dynamic, blast, and fatigue loads which make it important to examine again the more common construction materials, such as concrete and steel, the improvement of which will have an important effect on the national economy.

Modern research into these materials requires far beyond what has been included thus far in the scope and experience of the conventional metallurgist, engineer or scientist, because their study is no longer limited to the physical properties of materials. As an example, ceramics and mineral-like materials are becoming very important, and require development of unusual techniques for their fabrication and use. It has been found that these usually brittle materials may be ductile under certain circumstances also. The use of surface coatings is greatly expanded and promising, and the polymers offer unusual properties. Likewise the electronics industry has found significant expansion by the use of semi-conductors, with even more in promise for certain super-conducting materials used at cryogenic temperatures.

The analytic and test techniques have also become more complex. Analysis for molecular bonding, surface characteristics, and crystalline structure have been intertwined with difficult theories of solid state physics. The metallurgist, as we think of him, would have great difficulty in meeting the new demands. In fact, he would have to enlist the support of the solid state physicist, the chemist and the engineer. Clearly, a change in emphasis is needed from conventional research and education in materials to that involving extreme environmental conditions for which the researcher should have a broad background in

the various scientific fields. It is evident from conversations with several professors that these ideas are being rapidly developed at the educational level. This provides an example of the direct connection between research and education.

NSF Procedures

You may say, at this point, that my philosophical arguments are fine but ask "isn't the Government forcing this down the engineer's throat." The answer is no. First it is pointed out that it was Vannevar Bush, an engineer, who wrote the report "Science—the Endless Frontier" to the President, which resulted in the creation of the National Science Foundation. The National Science Foundation has been conscious from the very beginning that a few people—no matter how competent—in a government agency cannot master-mind science. Consequently, a complex of advisory panels and reviewers drawn from each scientific field to advise us what path to take is used. Even in the review of proposals, the referee system is used. In this system, experts in the particular field in question give opinions as to the scientific merit of the problem and the potential of the principal investigator. Thus, it is engineering scientists, not the Government, who are making the decisions as to what research is to be supported. The decision as to whether the research is basic or applied is made by engineers, principally, except when an engineer invades an area dominated by another field of science. In the latter case, he must compete with people from that field, but my past observations are that engineers are not at a disadvantage in this, and that engineers at this time of change are more critical of their own activities than the physicist or chemist who might be used for review.

Weak Points

Perhaps you now feel that the writer has expressed complete happiness with the Government research operation and support. He did not mean to do so. There is a serious lack of support of the more routine type of engineering research which is of great import because of its effect on the national economy. The ASME in their research publications calls this "background research." Reference is made to such work as the study of the fatigue of materials and the improvement of engineering analysis by adoption of computer methods. These are areas which are fundamental to progress and to economic development in industry but are so slowly accumulated or are needed by industries so diversely organized that they cannot be supported otherwise. The construction industry is a good example of such an industry. Their research provides a significant and worthwhile activity for engineers despite the fact that major "sputnik" type breakthroughs will not be accomplished. The writer is not alone in this belief. The following quote of Dr. James Killian is pertinent to this situation:

> As I look at the total spectrum of our research and development effort, I see deficiencies also in the area between basic research and development, the area that is sometimes called supporting research or component development or engineering research. After observing many research and development programs, I am sure that we would avoid costly mistakes in hardware development if we saw to it that the supporting research was done more thoroughly.

Nevertheless, a narrow interpretation of the enabling legislation prevents National Science Foundation from supporting such research. Engineers tell me they feel this violates the original intent and spirit of the National Science Foundation Act. If

enough engineers feel this way, they must either seek clarification of the law through Executive Order or modification of the law through Congressional action.

Despite the apparent lack of support in certain areas, sometimes it is astounding what schools will ask of the government. They seem to think that the National Science Foundation is willing to support most anything no matter how closely related to their regular duties. One must admit that it is oftentimes less trouble to propose projects to us than to industry, since it involves less "bush beating." Many projects that NSF receives could be supported by industry either directly or through its associations. Certainly most academicians realize the danger of Federal control of science by complete domination of research support. Dr. E. A. Eckhardt, formerly Assistant Director for the Mathematical, Physical, and Engineering Sciences at NSF, has remarked as follows about the situation:

> Every dollar of support first of all comes from some taxpayer somewhere in the United States. It gains nothing in potency by having made the trip to Washington and back. Should not the universities deal more aggressively with the problem of intercepting this dollar and saving it the wear of the long trip?

In regard to overhead, the Foundation has continually studied this problem to almost everyone's exhaustion since the inception of its research program. As a result of these studies NSF recommended "that in supporting research conducted in institutions of higher learning, agencies of the Federal Government, if requested, reimburse these institutions for those indirect costs associated with the direct cost of research supported." Essentially this means that each institution may request a rate in accordance with the "Blue Book" principles, or elect a flat rate of 25 per cent of salaries. The issue is now in process of resolution within the executive and legislative branches of the Government. In spite of this report the attitude still prevails among many agencies that the major purpose of the government program is to *assist* research and that the Government should not completely subsidize basic research. It is true, nevertheless, that the support programs are partnerships in which the Government and research institutions are joint participants and contributors. Federal funds are provided for the assistance, acceleration, or expansion of research studies which originate with the research scientist. Much of this research would be performed, regardless of Government support, but probably at a reduced rate or time delay. The low overhead rate is often justified by the fact that this allows a contribution by the university.

Today, economic and political stature is practically impossible if scientific and technological stature does not precede them. Since the struggle for this scientific supremacy will be won or lost in the research laboratories of our universities, we must support them at the level of our expectations and this includes full overhead payment.

The recent ECRC Survey of Engineering Colleges Research Capabilities * and Potentialities found that approximately 550 man-years of untapped research talent are presently available in the engineering educational ranks. This would require an estimated $10 million per year for full utilization plus a large investment in capital facilities.

* A *Survey of Research in the Nation's Engineering Colleges, Capabilities and Potentialities,* ECRC–ASEE, June 1958.

Tough Competition

The competition for "basic" research funds is tough. Within the National Science Foundation alone, six out of seven research proposals received are rated as meritorious and worthy of support. Yet only one out of four of these meritorious ones can be supported due to lack of funds. This is true for all disciplines within the Foundation. Nevertheless, vigorous complaints are heard from all quarters that there is unfair distribution of funds by scientific discipline. The truth is that the funds are so small everyone feels mistreated.

For example, a common criticism is that NSF does not support the young investigator, yet statistics show that last year over thirty per cent of the grants in engineering science went to young men under thirty-five. Another criticism is that NSF does not give grants to the smaller schools, yet current grants exist in forty-three states and such distribution could hardly exist without a large percentage going to those schools which are not renowned for their research. NSF, together with engineering educators, is well aware that the engineering research potential can be greatly improved by support of these two areas. NSF has learned, however, that it can do little until the school is ready to help itself. Sometimes a school seems to look at NSF as some sort of academic welfare fund. This is not the case; the law and history of the situation are clear; NSF is to support "basic" research, not the institutions doing "basic" research. The situation reminds the writer of a pack of hungry wolves chasing a scared rabbit. Any of the wolves could take the rabbit in one gulp, yet they must peacefully make a stew from the rabbit and give each some nourishment. It seems that all of us should put more effort into supplying more rabbits (a problem in basic research to be sure).

The Public

Usually engineers and scientists are sadly lacking in the line of communication with their fellow men. Some of them seem to think that support funds will increase and that there will be funds forever without any effort on their part. In a democratic society it is the public who decides in the long run what will be done. We must make special effort therefore to publicize the results of research in language understandable to them. This is a personal matter for each one of you. Researchers must face the fact that the public has been exposed to publicity which describes "basic" research as "useless" research. That basic research is the kind that "determines what makes fried potatoes brown." I'm sure that many people think that funds provided for "basic" research provide a sort of "slush" fund for the professors' entertainment. Yet recently when the "sputnik" incident occurred, we had a good example of how the purse strings can be loosened when those who hold them become aware of a critical situation. Researchers must learn to mesh gears with this public reaction so that we have support with more continuity if possible. You should not neglect your elected representatives in this information disbursement. If you like the type of support the National Science Foundation gives, tell these representatives. Keep in mind that the public does not like to support useless activities. Citizens expect to see useful results over the long haul. We must make them aware of these developments made possible by research as they occur.

EDUCATION FOR THE NEW ERA OF HIGH TEMPERATURE TECHNOLOGY: THE CHALLENGE TO CERAMIC ENGINEERING EDUCATION

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Presented to the Mineral Engineering Division at the 66th Annual Meeting of ASEE, June 17, 1958. Recommended by that division.

Introduction

Developments in high speeds and high energies have inaugurated the era of high temperature technology. One of the principal limitations of this new technology is materials: materials that can withstand the high temperatures generated without failure of any kind. Metals have experienced considerable attention primarily because of their favorable mechanical properties. However, it has become apparent that metals will be inadequate for the higher temperatures due to their poor resistance to oxygen and loss of strength at high temperatures. Ceramic materials, on the other hand, do not have these limitations; they are the potential materials of the future. The fundamental understanding and full engineering development of these materials, then, becomes a challenge to ceramic engineering education.

On the basis of the definition of engineering proposed by ECPD in 1957, "Ceramic engineering is the profession in which a knowledge of the mathematical, chemical and physical sciences gained by study, experience and practice is applied with judgment to develop ways to produce and utilize economically products formed from non-metallic inorganic materials for the progressive well being of mankind." Broadly speaking, then, the field of matter is covered by ceramics; metallurgy, a parallel field concerned with products of a metallic inorganic nature; and chemical engineering, primarily involved with fluids.

A brief review and analysis of the history and engineering requirements of ceramic products indicates the reason for the existence and general status of a challenge to ceramic engineering education. Education in this field was started at Ohio State University in 1895 to serve the needs of the traditional divisions of structural clay products, refractories and whitewares. Later, glass and porcelain enamels were included. These products were adequate to meet the demands placed on them by the structural industries which were the principal users. Consequently, close tolerances and other extreme mechanical and electrical characteristics were not demanded of them. Furthermore, metals were also satisfactory for most applications because of their property of ductility. Thus, there was no strong technical urge and it was economically unfeasible to attempt to make better ceramic products. Education was satisfactorily based on engineering practice used in production.

With the development of various technologies the demands on engineering materials became more exact-

ing. Metallurgy benefited by provision of funds for fundamental studies. It also benefited by the contribution of physicists who became interested in solid state studies and chose metals because of their simplicity in comparison with the complex ceramic materials.

The same factors are now active in the fundamental development of ceramics. Recent experiments on ductility of ionic materials have created a new optimism and a driving force for fundamental studies. The government through its various agencies is supporting a great deal of research on nonmetallic materials. Physicists and physical metallurgists, who have acquired a fundamental background on microstructures of metallic materials and their effect on properties, have become interested in non-metallic compounds. New materials and more accurate engineering data on conventional materials will undoubtedly result with all this activity. Ceramic engineering education is adjusting itself to the situation by critical reviews of its curricula.

Engineering Science of Ceramics

The demand for properties and precision beyond those obtained by conventional production techniques requires a fundamental approach: know-why, rather than know-how. Such changes are now taking place, both along physical and chemical lines.

Physical Ceramics. Relationship of structure to properties of materials is already recognized as an engineering science. Physical metallurgy is part of it. Physical ceramics is also part of it although the state of the knowledge is not as yet as far advanced. Considerable research is now in progress and in time there should be activity parallel to that of physical metallurgy. The development of physical ceramics and a course covering the subject is a challenge that is being met.

The specialized scientific fundamentals upon which this engineering science is built up are solid state physics, kinetics, crystal chemistry and surface physics and chemistry. This core of subjects also constitutes the fundamentals for the study of metals and accounts for the accelerated and extensive research program in physical ceramics by physical metallurgists as well as the ceramic engineers.

An illustration of the importance of driving forces for work in certain fields is that of ductility of ionic cubic crystals. The first experiments illustrating the ductility of sodium chloride were made in 1928, but they were not followed up. They were interesting but there was no economic driving force for continued and extensive research along those lines. There were also popular fallacies that discouraged work with ceramic materials—that oxides had bonds that could not be broken and remade without fracturing the piece. The recent experiments with magnesium oxide indicated that oxides had inherent ductility. Now, however, the great need for high temperature engineering materials has caused a tremendous reaction to this experiment with a resulting strong driving force for continuing work. The challenge to ceramic education is to absorb this and other work in this field, continue and expand it, and incorporate it into the proper courses. Many new developments in ceramic materials should consequently arise in the next years.

Chemical Ceramics. Chemical changes and reactions of materials at high temperatures are just as important as their physical properties. Considerable work is now in progress pursuing this phase. This work includes high temperature stabilities of

compounds alone and in contact with gases, vapor pressures and vapor species, and solid state reactions. Specific subjects used for a background include thermodynamics, phase relationships, kinetics, crystal structures, and surface chemistry. This overall field is frequently referred to as high temperature chemistry.

Again, the same historical pattern is evident. Early experiments were interesting but the driving force for continuing work was weak because of the low economic interest in very high temperature processes. This situation was changed with the development of atomic energy. Crucibles of special refractory materials with very low reactivities were a necessity. This work has expanded and considerable activity is now in progress.

This type of knowledge certainly must be part of the scientific base of ceramic engineering. The challenge constitutes the inclusion of this material in the curricula.

Unit Operations of Ceramic Engineering

Until recently the ceramic engineering curricula included engineering practice courses in each of the principal product branches of the industry. This approach was adequate to meet the demands of the traditional industry. The situation, however, is becoming untenable. With all the other subject matter that is now considered to be essential in an engineering curriculum, and with the additional requirement of special engineering science courses to provide a proper background for studies in physical and chemical ceramics, the problem of available time becomes critical.

The only answer to this situation is elimination of courses by condensation of common subject matter. The chemical engineers were faced with this problem years ago and solved it by development of unit operations and unit process courses. The same situation now exists in ceramic engineering and in time all the curricula will also have unit operations courses.

Another advantage of this development is the emphasis that is placed on the unit operations themselves. This situation has created a greater awareness of the deficiencies of the knowledge on the basic fundamentals of the processes themselves. It is now apparent that research in this field is just as necessary as in the engineering sciences in order to meet the more exacting specifications and to attain desired microstructures.

The unit operations characteristic of ceramic engineering deal with the treatment and forming of products from non-metallic inorganic solids and slurries and plastic masses containing such solids. As an example, the study of rheology of mixtures is necessary for a fundamental understanding of the forming processes.

The challenge to ceramic engineering education in this case is the development of unit operations courses and their inclusion in the curricula.

Conclusions

In conclusion, then, the challenge to ceramic engineering education presented by the new era of high temperature technology consists in the development of a strong scientific approach to the study of non-metallic inorganic materials and also the development of a strong unit operations approach to the production processes. The former is accomplished through participation in and contribution to the engineering sciences of physical ceramics and chemical ceramics or high temperature ceramic chemistry.

The ceramic engineer, thus, will be concerned with the production of non-metallic inorganic articles. An

engineer trained primarily in physical ceramics will be closely allied with one trained in physical metallurgy, because the scientific fundamentals on which both are based are common and neither may be concerned with the production of an article from the raw material stage. A combination of these phases is not difficult and is reaching accomplishment at Berkeley. A person trained in this manner would become the materials engineer.

CANADIAN COLLEGES AND UNIVERSITIES ENGINEERING REGISTRATION

The Engineering Institute of Canada has released the results of its annual survey of engineering registration at Canadian universities and colleges. The tabulations were prepared from lists obtained direct from the university registrars, and compiled at Institute Headquarters in Montreal.

The grand total of the enrollment now stands at 14,552 as compared with 14,247 a year ago. This increase, slightly over 2%, is the smallest rise for quite a few years. This year's survey discloses a sharp drop in the number of new engineering students starting their courses this year. The total new class number 4,572 against 5,132 last year, a decrease of 11%.

A slight decline is expected in 1959 graduates. If students presently in their final year complete their courses, 2,104 will graduate and enter the profession next spring. This follows an estimated figure of 2,130 for 1958. If the forecast proves accurate, it will mark the first time that the size of the graduating class has fallen off since the student veterans left the scene.

There now are 30 educational institutions in Canada where some kind of an engineering course is offered, and 15 of these now grant degrees. An examination of the results in the different faculties shows a steadily increasing interest in the study of engineering physics. Total enrollment in this branch now stands at 727, which is an increase of 12½% over 1957.

CURRENT TRENDS IN HEAT TRANSFER AND THEIR EFFECT ON UNDERGRADUATE TEACHING

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Presented at the Joint Conference of the Chemical Engineering, Civil Engineering, Electrical Engineering, Mechanical Engineering, and Physics Divisions, June 19, 1958, at the 66th Annual Meeting of ASEE in Berkeley. Recommended by the Mechanical Engineering Division.

At the Conference on Science and Technology for Deans of Engineering held at Purdue University in September 1957, Dean George A. Hawkins made certain remarks among his other opening statements pertaining to the history of that conference, and I would like to quote from them.

The complete proceedings of that meeting have already appeared in book form [1] sans, unfortunately, the lively discussions reported to have followed some of the talks. Certainly that conference, as pointed out by Dean Hawkins, augments the work of the ASEE and of the professional societies and, although I have not read them in their entirety, there are parts of the proceedings which ought to be of direct and considerable interest to many of us here today.

I now quote from Dean Hawkins' remarks.

During the past twenty years we have all observed unbelievable developments in science and technology. The impact of the new concepts will have a profound influence on engineering education now and in the future.

As pointed out by Norman Barish and others, there is a critical shortage of engineers in two categories in particular, namely:

1) Engineers having an educational background oriented toward mathematics and sciences.

2) Engineering graduates having unusual analytical and design ability.

The first group is comprised of those primarily interested in the research and development functions. Those in the second group are interested chiefly in professional engineering work. In addition to these two classes, industry now uses, and will continue to use, large numbers of engineers interested in such functions as production, maintenance, sales, etc. The existing programs of study may or may not be suitable for the education of the engineers of tomorrow. We, as engineering administrators have a great responsibility in the study and design of educational programs.

May I add that we, as engineering educators, share in that responsibility, at least from the viewpoint of our special fields of interest. And so, this afternoon, I would like to offer a few ideas on some current trends or, in a more accurate sense, important present-day topics in the field of heat transfer, and try to point out why they are important to the teaching of undergraduates and, in an instance or two, *how* they might be treated, or *how* they are being treated.

[1] "Recent Advances in the Engineering Sciences—Their Impact on Engineering Education," Proceedings of the Conference on Science and Technology, McGraw-Hill, New York, 1958.

Role of Mathematics

I would like to begin with the recognition that college students in engineering are receiving more extensive mathematical training than the students ten or more years ago. Today the formal mathematical requirements carry a student through differential equations, and in the curricula of a number of engineering schools, this requirement is satisfied by the end of the sophomore year. It is important, then, that this more adequate preparation be exploited to the fullest extent so that the student can get the maximum benefit from his undergraduate training. Industry recognizes the value of the better mathematical background in the engineer's work, and is beginning to rely on it in the engineers that they hire.

In heat transfer, particularly in dealing with conduction problems, but in other topical areas as well, such as the boundary layer, it is apparent that the mathematical training that the students have is not being utilized to the fullest. One need only examine the current undergraduate textbook treatment of conduction problems in more than one independent variable to see that this is so. Certainly the concept of the partial derivative has been introduced to the student in the calculus; any good undergraduate calculus book may be consulted to see that this has been so for a long time. Herewith, the development of the general three-dimensional unsteady-conduction state heat equation can be brought about applying the first principle of thermodynamics and the rate equation. One can readily arrive at a general result—say the Fourier-Biot equation, which may even include uniformly distributed heat sources—and then proceed to some solutions of reduced forms of the equation. In my experience, the students have not found too much difficulty in understanding and working with the mathematical technique of the product solution and resulting separation of variables in connection with the solution of one-dimensional unsteady-state heat flow, governed by the so-called parabolic equation.

One cannot carry out adequate analysis in a subject such as the engineering science of heat transfer, in which the development of analytical thinking plays a sizable role, without adequate use of mathematics. The one independent variable problem has too limited application and, since the student has the mathematical background to handle more involved problems allowing extension of principles to two or more variables, I say why not use it?

Importance of the Boundary Layer

In the field of convection it is not sufficient any more to synthesize correlations on the basis of dimensional analysis alone without giving proper insight into the mechanisms that underlie the convection phenomenon. In this connection, one should introduce the concept of the hydrodynamic and thermal boundary layers at some stage of the treatment of convective heat transfer. Needless to say, one cannot discuss convection without discussing at the same time the fluid flow, the two phenomena being inseparable.

A few words about the boundary layer are in order here to place it in its proper perspective from the viewpoint of its importance in heat transfer today.

The introduction of the concept of the boundary layer by Ludwig Prandtl back in the year 1904—which, incidentally, came to Prandtl while he was in the midst of designing an exhaust system to remove wood shavings and sawdust from a pattern shop—certainly places it on a time scale

as something outside of a current development; it is, however, a modern idea of tremendous practical importance and with consequences in fundamental research, in development, and in design that *are* current and far-reaching in the domain of heat transfer and fluid flow. A very large portion of the significant engineering work in the heat-transfer field carried on in the last 15 or 20 years, and still being carried on vigorously at the present time, stems directly from the boundary layer concept.

It may be recalled that Prandtl, in his now classical work of 1904, hypothesized that the flow of a fluid about a solid body can be divided into two regions, one being a relatively thin layer near the surface of the body in which viscous forces predominate (called the boundary layer), and the remaining region outside this layer where frictional effects may be neglected. Herewith, he took the initial and giant step to reconcile and unify two formerly divergent branches of the science of fluid mechanics, the science of *theoretical hydrodynamics* which evolved from Euler's equations of motion for a frictionless, non-viscous fluid, and the empirical science of *hydraulics,* which was based on experimental data. The latter science was given birth by the needs of engineers and applied scientists who required answers to pressing practical problems precipitated by the industrial revolution, problems such as those of pressure losses in pipes and channels and the basic problem of drag force on bodies moving through real fluids.

Subsequently, with the introduction of the concept of the thermal boundary layer, basic insight into the convective heat transfer in pipes and channels, as well as the heat transfer from solids to fluids, was gained; moreover, one obtained directly from thermal boundary layer analysis a theoretical prediction of the local coefficient of convective heat transfer in terms of the temperature gradient at the solid-fluid interface, and mean values of the coefficient can be obtained by integration. That the boundary-layer theory leads to accurate predictions of the heat transfer is well established.

The principal motivation to explore flow problems in terms of boundary layer theory was originally supplied by man's interest in flight. Rapid extensions of knowledge, born of wartime researches in flight at high-speed and in ballistics and rocketry, have carried us to a host of heat-transfer problems on missiles and space vehicles leaving and entering the atmosphere.

The intense heating effects produced on surfaces past which fluids flow at very high speeds are in many instances wholly or partially tractable by a boundary-layer type of analysis, albeit new dimensions of complexity may be added. One may cite as an example the cooling of a surface by the introduction of a fluid through pores in the surface, *transpiration cooling.* In this case the material transport process is involved as well as the energy transport process. A more complicated phenomenon is that of *ablative heat transfer* in very high-speed bodies. In this type of heat transfer, material at the solid surface of the body changes phase and may be partially vaporized and partially swept away. It is my understanding that some inroads on the ablation problem have been made using boundary layer theory as a basis for analysis.

It would not be correct to allow the inference to be drawn from the above brief remarks on the boundary layer that all of the less severe convective heat transfer problems have been ade-

quately treated. There still remains much work to be done both analytically and experimentally. But it is fair to say that substantial progress has been made in both free and forced convection using boundary layer theory for a rather large number of simply defined flow configurations. These defined configurations include flow over cylinders, normally and axially, over spheres and along flat plates, flow in channels and pipes, and over bodies of revolution and other shapes.

The above brief sketch serves, I trust, to illustrate the importance of the boundary layer concept in engineering practice today. It has given us an extremely fruitful approach to the solution of many important problems involving transport processes. Many of the existing analytical solutions obtained using boundary-layer analysis, along with experimental evidence which corroborates the theory, are current to engineering practice.

There appears to be little or no question that so important and useful a concept should be introduced into the undergraduate course in heat transfer, whether the course is taught to mechanical, chemical, electrical, civil or other engineering students. The question seems to be *how* can it best be done.

Teaching the Boundary Layer Concept

Undoubtedly a consensus of those involved in teaching undergraduate heat transfer would indicate, on the one hand, that the introduction of the complete general equations governing the motion of real fluids, along with the general equation for heat transfer in a moving fluid, would, under present conditions, prove almost meaningless to the undergraduate student because of the lack of adequate background to comprehend them. On the other hand, the least that probably should be done is to present a thorough qualitative picture of the boundary layer and its essential characteristics along with the meaning of shear stress and coefficients of heat transfer in terms of, respectively, the velocity gradient and temperature gradient at the surface. This descriptive approach might also be carried out for the free convection on a vertical surface to point out the unique character of the velocity profile for this case, i.e., the zero velocity at the surface (no-slip condition) and the asymptotic approach to zero velocity at large distances from the plate, with the maximum velocity in between. Similarity of the velocity profiles and of the temperature profiles should be brought out.

A somewhat better approach is that of presenting, in addition to a thorough qualitative discussion, the integral form of the momentum and energy equations, with some simple applications, as is done in the latest (3rd) edition of the Jakob and Hawkins text.[2]

Perhaps the best approach to the equations of the hydrodynamic and thermal boundary layer is the fundamental, yet rather elementary, treatment presented in the new text on heat transfer by Giedt.[3] Here, the hydrodynamic and thermal boundary layer equations are derived for flow along a flat surface, and then the author demonstrates their application. Also, a clear picture of the meaning of the local coefficient of heat transfer in terms of temperature gradient at the heat-transfer surface is presented, as well as the integration to obtain average values.

While it is claimed by Professor

[2] M. Jakob and G. A. Hawkins, *Elements of Heat Transfer*, John Wiley and Sons, New York, 1957; pp. 143–151.

[3] *Principles of Engineering Heat Transfer*, D. Van Nostrand Co. Inc., New York, 1957; pp. 135–139.

Giedt that his treatment does not transcend the background that the average junior engineering student has acquired, it may well represent the limit of what the *average* student can handle at the present stage of engineering education. Admittedly, the better students should have little trouble with it. So much for the boundary layer.

Liquid Metals as Heat Transfer Media

A consequence of the advent of nuclear power has been the use of liquid metals and liquid-metal alloys as heat transfer media. These metals include sodium, potassium, mercury, bismuth, and lead, and certain of their alloys. Of these, mercury, because of its use in binary-vapor power cycles, has the longest history of practical application as a heat transfer medium. The liquid metals as a group possess thermodynamic and heat-transfer characteristics that make them second only to water as desirable heat-transfer media for reactor heat removal,[4] and water has the considerable disadvantage from the viewpoint of mechanical design of the high pressures associated with high temperatures, such as those experienced in reactor operation.

The whole of reactor technology is so complex that it involves practically all of the engineering disciplines as well as the fields of theoretical and experimental physics and chemistry. From the viewpoint of the heat-transfer engineer or the power engineer a power reactor can be considered as another energy source, admitting, however, that it has thermal and design problems and limitations which are unique unto itself. The use of liquid metals gives rise to some of the difficulty because they pose difficult handling problems, although, as in the case of compact atomic reactor design, they provide the most effective cooling and they take advantage of high temperatures and high rates of energy release per unit volume.

Because of the promise of liquid metals,[5] which have high thermal conductivities (compared with other fluids) and low viscosity, giving low Prandtl numbers, some attention should be paid in the undergraduate teaching of heat transfer to their special features and to the mechanism of heat transfer involved. The Jakob and Hawkins text[6] discusses the mechanism and presents the theoretical equations of Lyon and of Seban and Shimazaki for liquid-metal flow in a tube; Giedt's book[7] discusses characteristics of this class of fluid media, presents property values (from the *Liquid Metals Handbook*), discusses the lead-bismuth experiment of Johnson, Hartnett and Clabaugh, and also presents the theoretical equation of Lyon, as well as the empirical equation of Lubarsky and Kaufman; the text of Brown and Marco[8] gives a very much abbreviated account of liquid metal heat transfer, including the Lyon approximation to Martinelli's equation.

For a more comprehensive treatment as background material, reference is made to the late Max Jakob's second volume of *Heat Transfer*.[9]

[4] *Liquid Metals Handbook*, Section 4.1, U. S. Govt. Printing Office, Washington, D. C. 1952.

[5] It may be recalled that another rather old use of a liquid metal because of its superior heat-transfer characteristics was in the automotive engine sodium (core) valve.

[6] P. 142.

[7] P. 183.

[8] A. I. Brown and S. M. Marco, *Introduction to Heat Transfer*, McGraw-Hill, 1958.

[9] *Heat Transfer*, Vol. II, John Wiley & Sons, New York, 1957; chapter 4.

Conduction with Internal Heat Generation-Additional Examples

It is pertinent to our subject that the solid-fuel type of nuclear reactor, aside from giving rise to convection problems in which liquid metals or boiling water are involved in channel flow, also presents us with some interesting variations on the basic problem of conduction in solids with internal heat production. The heat generation takes place in the fuel while subjected to the neutron flux. Interesting variations on the boundary conditions occur because of the shape of the fuel element, such as plate-type or rod-type, and because the highly-corrosive fuel is invariably clad in a protecting metal which does not generate heat itself. This problem, as one recognizes, is governed by the Poisson equation either in one dimension or in cylindrical coordinates for the geometries mentioned above.

The usual heat production problems arise in electrical conductors and in bodies made up of windings, items of interest to the electrical engineer primarily, but other applications are to be found, under suitable approximation, for instance in a reacting chemical solid (endothermic or exothermic) or in the cooling of concrete.

Glasstone [10] gives several examples of the internal heat production problem with a number of interesting combinations of geometry of clad elements and various boundary conditions. Heat generation in reactor fuel elements allows for greater variety in problems in the course of teaching. Incidentally, Glasstone demonstrates the calculation of the energy release from the fission rate, which may be of interest in tying in a heat transfer course with a course in reactor design or perhaps atomic physics.

Heat transfer between a surface and a fluid in which internal heat generation occurs, such as would be the case in a slurry-type reactor of, say, uranyl sulfate, transcends the scope of the present undergraduate treatment of heat transfer.

Numerical Analysis in Heat Transfer

Another area in which considerable progress has been made since World War II deals with the application of numerical methods to the solution of heat transfer problems. With each passing day industry is becoming more and more computer conscious in all phases of company operation, and somewhere along the line the student should be familiarized with the power and engineering value of numerical analysis. Although the more complex problems are usually handled by machines, the value of "hand-type" numerical solutions for certain non-routine problems whose specifications place them outside of the class for which closed form solutions are available, should not be overlooked. Often, when rough engineering answers are sought—answers say whose desired accuracy is comparable to that with which the physical constants are known—the *numerical* method, involving either relaxation or iteration in space or time, proves invaluable.

In the area of heat transfer, subsequent to the predecessor work dealing with the graphical solution of the parabolic equation for heat flow by Binder and Schmidt (which we recognize as a special case of the more general equation), the numerical method has received considerable attention and many ramifications of it are widespread. Since the appearance of Emmon's signal paper in 1943, a great number of typical steady, unsteady, and quasi-stationary state

[10] S. Glasstone, *Principles of Nuclear Reactor Engineering*, D. Van Nostrand Company, New York, 1955; pp. 654–668.

problems have been solved, including those involving internal heat sources or sinks and with time-dependent boundary values, surface conductances, or environment temperature for the unsteady state. Any compatible combinations of the above features may be allowed to occur, with the added feature of arbitrary initial temperature distribution within the solid (if the problem is an unsteady state one). Dusinberre's text [11] on numerical analysis (unfortunately now out of print) contains a large assortment of problems for both steady and unsteady state, as well as a problem on the quasi-stationary state (from Rosenthal's analytical work on moving heat sources), and it demonstrates conclusively the flexibility and utility of the numerical method. Jakob and Hawkins have in their text treated the elements of the numerical method rather thoroughly. The numerical method of relaxation has also been extended to problems of body convection using both the relaxation method and also iteration.

Whether one views the numerical solution as one in which the governing differential equation, derived for a continuum, has its terms replaced by approximating partial or total difference quotients, as the case may be, or whether, as Dusinberre seems to prefer, the body is constituted of discrete parts with each of which is associated a given temperature, is of no difference as regards results. In the difference-quotient scheme, the quotients themselves find their equivalents in terms of the values of the function at a (nodal) point and in terms of the values of the neighboring points. In both considerations we need only apply the first principle of thermodynamics and the rate equation for heat transfer. In the one case we sort of backtrack from the limiting process which in itself defines the derivative; in the other we never pass to the limit. It is a matter of point of view, except for the important fact that in the process involving backtracking we have committed what amounts to a truncation error whose order of magnitude is known.

I would like to mention one relatively new innovation of the numerical method of relaxation which may not be too well known as yet. *Relaxation*, which is a numerical method for solving a system of linear algebraic simultaneous equations, has been applicable to boundary-value problems governed by the LaPlace or Poisson equation. In April of 1955 the late Dr. G. Liebmann of England published a paper [12] in which he showed that by choosing a suitable finite-difference approximation, the parabolic partial differential equation governing unsteady-state heat flow can be converted into a series of boundary-value problems of the Poisson type, each with specified boundary conditions, which can be solved using Southwell's relaxation technique. I will only take the time here to mention that he takes a "backward" step in time instead of a forward one, and thereby obtains an equation in four unknowns and one known at the end of the time interval. The solution is very stable for *all* values of $\overline{\Delta x}^2/\alpha\Delta\tau$, the key parameter in the problem.

The new equation and its treatment is no more difficult than the one presently employed in the undergraduate teaching of numerical methods, and it allows the choice of relatively long time intervals without the danger of finding an oscillating or diverging solution.

[11] G. M. Dusinberre, *Numerical Analysis of Heat Flow*, McGraw-Hill, New York, 1949.

[12] "The Solution of Transient Heat Flow and Heat Transfer Problems by Relaxation," *British Jour. of Physics*, VI (April 1955).

It may be worth mentioning along with these remarks on numerical methods that Scarborough, in the latest edition (3rd) of his treatment of numerical analysis,[18] gives a very readable account of the comparison of the numerical methods of *relaxation* and *iteration*, citing advantages of one method over the other.

Use of the Electrical Analogy

Analogic methods, and in particular electrical analogs, have been used for a long time in the solution of heat transfer problems. They date back at least as far as the early work of Langmuir on the study of heat flow through edges and corners, published in 1913. The electrolytic-tank method used by Langmuir in his early work, and subsequently in some industrial laboratories, has yielded to the electrical-resistance network and to electrically conducting sheets for two-dimensional studies. Presently one has at his disposal the electrically-conducting Teledeltos paper which is commercially available from Western Electric Company, and which can be used very effectively in the classroom demonstration of the electrical analog for a simple-two dimensional resistance circuit. One can also include surface conductances using this method.

If one adds the time variable, then electrical capacitance, analogous to the thermal capacity, must be properly introduced and the equivalent electrical circuit operates with continuous physical variables, and we have a thermal analyzer. In such a device the ideally distributed resistance-capacitance circuit is replaced with "lumped" resistance and capactance which finds its equivalent, mathematically, in terms of a finite-difference approximation to the governing differential equation.

These underlying ideas concerning electrical analogs have been extended to the solution of many complex heat-transfer problems. It suffices to say that the literature abounds with variations of such analog treatments and attests to their importance in the heat transfer field.

Here, again, at least some simple treatment of the subject at an undergraduate level, just to get across the underlying ideas, appears warranted.

At the same time it must be recognized that analog and digital computing devices, which are becoming more and more involved in engineering work in industry, far transcend the heat-transfer field. And so one cannot hope to include, as a general thing, the treatment of computers in an undergraduate course on heat transfer. Extrapolating the present trend of computer applications in industry, engineering educators may soon be faced with the prospect of introducing a course into the already crowded curriculum, dealing with the principles and applications of computing devices to engineering problems. But that is another matter indeed, and it involves *methodology*, not basic principles.

Summarizing:

1. The increased emphasis on adequate mathematical training of the undergraduate engineering student today, manifest by the increase in the level of mathematical training included in the various engineering curricula, allows for a more penetrating and meaningful treatment of the subject of heat transfer, as well as for other subjects. The opportunity to utilize this in undergraduate teaching should not be missed.

2. The boundary-layer concept is basic to the clear understanding of

[18] J. B. Scarborough, *Numerical Mathematical Analysis*, 3rd Ed., Johns Hopkins Press, 1955.

convective heat transfer, and its consequences are of such immense practical importance that introductory treatment of it should begin at the undergraduate level.

3. The advent of nuclear power and the unique requirements of reactor design have introduced liquid metals and liquid-metal alloys as heat-transfer media. Some treatment of these low Prandtl number fluids and their thermal characteristics appears desirable. Also, additional interesting and useful problems, at the undergraduate level, arise from the heat generation in the reactor fuel elements.

4. Numerical methods provide a powerful tool for the solution of heat-transfer problems, and a basic treatment of this subject is invaluable to the student in obtaining solutions of engineering accuracy to problems he otherwise might not be able to solve. The relaxation method allows for "hand-type" solution, whereas iteration leads to the use of a digital computer.

5. The electric analog is valuable in the solution of heat-transfer problems and, therefore, the analogy between the flow of electricity and the flow of heat should be introduced at an early stage in the treatment of heat conduction; in fact, it sometimes happens that the student grasps the fundamental law of heat conduction—Fourier's law—only after the simple analogy is drawn with Ohm's law. Also, introduction to the resistance-capacitance type of analog network would provide a basic understanding of thermal analyzers, which are of current practical interest in more advanced phases of the analog treatment.

The above survey of items of current importance in the undergraduate field is obviously not intended to be a comprehensive or exhaustive coverage of the present-day needs in teaching heat transfer. It simply constitutes a presentation of some ideas on a few selected topical areas within the framework of the heat-transfer field, perhaps biased to a certain extent by a mechanical engineer's point of view. All of the topical areas touched on, however, relate to things of current practical importance to the engineer who must deal with heat transfer problems, and so, it would appear, an adequate introduction to the principles and underlying ideas they involve should be considered while he is in college.

That the topics dealt with here have taken on increased importance is supported by the fact that even as recently as ten years ago most of them were not even mentioned in undergraduate heat-transfer courses, whereas within the past few years they have been coming more into evidence, to one degree or another in undergraduate texts.

Of course it is not easy to come up with an accurate picture of the subject matter being taught in undergraduate courses in our colleges today. Curricula are designed somewhat differently; also teachers invariably are selective about the topics to be covered in the text, so the text, if one is used, is only a rough indication of the course content. Moreover, many teachers augment the text treatment with additional notes and problems they feel are important.

In the heat-transfer field, however, there is a group actively engaged in the survey of what is being taught at the undergraduate level, the Committee on the Teaching of Heat Transfer organized under the Heat Transfer Division of the ASME. This committee, has been engaged for over a year in the collection of detailed information such as course offering(s), major department of students being taught

texts used and sections covered, type and content of auxiliary materials being used, additional topics covered, etc. Anticipating that someone here might ask the question, "What would one do with the results if and when they are collected?", I would be tempted to reply: "Force the colleges and universities throughout the country to produce accurate course descriptions in their catalogs, at least for heat transfer."

Finally, these thoughts, which I may term a plea (without passion) for the student and the curriculum. There are those of us who have chosen the science of heat transfer as a major area of interest in our professional lives and, therefore, in addition to teaching the subject to undergraduates, we carry on graduate research and other related activities. It is natural that one may generate quite an enthusiasm about his favorite subject, and it is understandable that he attempts to transfer this enthusiasm to the student, at least to the better students. As in other fields, professors are constantly looking for promising disciples for advanced undergraduate projects and for the graduate school. In the midst of this enthusiasm and search one should be mindful of the fact that his own subject material constitutes only part of a rather broad spectrum of subjects which lead to the Bachelor's degree. The Bachelor's degree is still very much a terminal program in our scheme of higher education in engineering, and it appears likely that it will remain so, at least for the near future. We, ourselves, are part of the broad pattern of the educational process, and so it appears that our objectives should center around the student's mastery of the basic principles underlying the heat-transfer field and not around the production of a few expert students at the expense of the other students. The training of specialists is indeed another matter. Regardless of his professional bent after graduation, the student will be confronted soon enough with the fact that ours is a non-isothermal world.

AERO DIVISION—IAS JOINT MEETING

The sixth annual joint meeting of the Aeronautical Division and the Institute of Aeronautical Sciences will take place Thursday morning 29 January 1959 in the Hotel Sheraton Astor, New York City. A panel discussion on "Space Technology and Engineering Education" will be moderated by Division Chairman, Colonel G. C. Clementson, with such eminent people as John P. Hagen, Director Project Vanguard and Fred Singer, University of Maryland taking part. The program is being arranged by A. Wiley Sherwood, University of Maryland and A. L. Cronk, Texas A & M.

UNIVERSITY COMPUTING COURSES

BRUCE GILCHRIST

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Few people dispute the importance of the electronic computing machine in modern business and industry. The position of university courses in the use of such equipment is, however, very much more debatable. This was brought out at the 1957 Annual Meeting of the Association for Computing Machinery when, in a discussion on the universities' role, directors of the university computing centers could not agree even among themselves as to what the role should be.

Some considered that programming and coding courses had places in university curricula, while others were actively opposed to such innovations. The main cause for alarm seemed to be that such courses *could* teach purely techniques, and thus would have little or no real educational value. One may note in passing that the definition of "real educational value" is by no means clear. A discussion of this question is, however, outside the scope of an article such as this.

The first purpose of this article is to attempt to allay this alarm by presenting what, in my opinion, is required in a programming and coding course if it is to be of true educational value and worthy of a place in our university curriculum. Secondly, a proposal as to the integration of such a course into the regular curriculum is made.

In our modern large universities with their great number and variety of offerings, it is comparatively easy to find some presently offered techniques course with which to compare our programming course, and to justify our programming course as less technique oriented. While this argument has its uses, it is better surely to compare our courses with the best ones given rather than the worst.

In his recent book *Digital Computer Programming*, McCracken suggests that programming a problem for solution on a digital computer is basically a process of translating from the language convenient for human beings to the language convenient for the computer. Certainly if we discuss ways of handling this general problem in our programming courses, we can not be accused of teaching only technique. As in the study of languages, however, the interrelationships between one language and another cannot be understood without a good working knowledge of one or more languages.

So in the case of programming, little concrete understanding of the problems involved can be obtained without knowing how at least one computer works and how the problems of communicating with it are handled. This, of course, requires the teaching of some technique. I am not prepared to agree, however, that this is a bad thing, as long as it does not become the sole aim of the course. Handled correctly, the technique should provide the foundation and the laboratory tool upon which and with the aid of which a general understanding of the problems encountered in communicating with a modern high speed digital computer can be taught.

Now that a good many universities have obtained computing machines for research and instructional use, the

course problem is an immediate one, aggravated by the sparseness of textbooks and teaching tradition. Since it is easy in such a situation to teach technique because it is the simple way out, we must be on our guard. Probably the most common machine in the universities is the IBM 650, and, in my opinion, this is a very suitable machine for educational purposes. Nevertheless, if we teach a course on "Programming and Coding for the IBM 650," as one book publisher suggests, we will be failing in our aim of providing a course of real educational value.

This is not to deny that there are many people on our campuses who just want to learn the techniques so that they can solve their individual problems. These faculty members and research students should indeed be taught the technique, but let us not call such "cook book" instruction a formal course in programming and coding.

Two Courses

At Syracuse University we have introduced two programming courses. The first, entitled "Programming and Coding for Digital Computers," is a one-semester, three-credit course. Using the IBM 650 as our foundation and laboratory tool, we introduce the student first to flow charting and then to the various methods of coding, attempting as we go to bring out the general characteristics of the methods as well as the details involved in performing examples on our IBM 650.

As an integral part of the course, the student has to program and code at least one reasonable-sized problem for the 650. We prefer to have students choose problems of interest to themselves so that they will learn something of the potential of high-speed computers in their chosen fields. While we are by no means completely satisfied that we are as yet teaching enough about the general or non-technique aspects of programming and coding, we do feel that eventually we will build up a course which has true educational value.

The second programming course, entitled "Seminar on Digital Computers," is devoted to student reading and discussion of topics such as automatic programming and the relationships between the overall system design and the type of problems to be solved. The student is assumed to have a good working knowledge of the operation of one computer (usually the IBM 650). Therefore, the course deals with the problems of computer use in general, with examples taken from a great number of computers.

Technique

Now, what do we provide these people who just want to learn technique? This varies according to the number of people interested at a given time and the maturity of the people involved. Some find that they can pick up enough just from reading a coding manual (in our case, this is frequently the one describing the Bell Interpretive System). For others we arrange short technique classes. Finally, there are some who take the first programming and coding course mentioned above. The fact that people primarily interested in technique do take the regular credit course need not detract from the educational value of the course provided that they are not allowed to set its pace and direction.

The stage in a student's college career at which programming courses should be taken will undoubtedly play a part in setting the standard of the courses. We prefer that the students in our first programming course have a good working knowledge of

their own field so that they can rapidly appreciate the possible applications for computers in that field and be able to complete a satisfactory term problem. Thus in the case of mathematics, science, and engineering students, we like them to have had at least one semester of an introductory numerical analysis course. Similarly we like business students to have taken the core business courses and preferably also a course on punched-card equipment.

Because numerical analysis is seldom taught earlier than the senior year, the above requirements would appear to exclude a mathematics major from taking even the first programming course until the second semester of his or her senior year. This need not, indeed should not, be the case with students for whom the bachelor's degree will be the terminal, or who, even though they are considering taking some graduate work, are primarily interested in industrial mathematics. For these people I would like to propose the introduction of a mathematics and computing major.

Mathematics-Computing Major

This new major would be primarily mathematics with sufficient emphasis on computing to help the student become an expert programmer and coder efficiently if he enters the computing field immediately after graduation. On the other hand, the courses would not be so practical as to hinder the student who during his senior year or even after graduation decides to take graduate work in mathematics. The proposed sequence of mathematics courses with number of credit hours involved is as follows:

Freshman year:	1st semester	Analytic Geometry (3)
	2nd semester	Differential Calculus (4)
Sophomore year:	1st semester	Integral Calculus (4)
	2nd semester	Advanced Calculus I (3)
		Elementary Linear Algebra & Matrix Theory (3)
Junior year:	1st semester	Advanced Calculus II (3)
		Numerical Analysis I (3)
		Statistics I (3)
	2nd semester	Partial Differential Equations (3)
		Numerical Analysis II (3)
		Programming & Coding for Digital Computers (3)
Senior year:	1st semester	Complex Variable (3)
		Statistics II (3)
	2nd semester	Seminar on Digital Computers (3)

In addition, the student should be required to elect nine more credit hours of mathematics, mathematical physics, or another approved subject during the senior year. This brings the mathematics requirement for the junior and senior years to 36 hours, and for the freshman and sophomore years to 17 hours, thus leaving 67 hours for other liberal arts subjects. For students with adequate high school mathematics, the course in analytic geometry will not have to precede the initial calculus course. The following courses can then be arranged accordingly, leaving another 3 hrs. free for an elective.

The programming courses in the

above sequence have been timed to come when the student will have been introduced to the practical applications of computers, e.g., in numerical analysis and statistics. It will further be seen that even if the student decides at the end of his senior year to proceed with graduate work in pure mathematics, he will still have an adequate background.

Why in Mathematics?

Throughout the above discussion it has been assumed that the Mathematics Department should be responsible for teaching programming courses. There are two alternatives to this. First the course could be given by one or more departments as the need arises for students of those departments to know something of computers. Secondly, an entirely new computing department could be set up. In examining the merits of the first alternative, we should bear in mind the example of statistics. With few exceptions, when the teaching of statistics has been spread among many departments, it has not only resulted in the weakening of the rigorous courses given by the Mathematics Department, but has led to a multitude of "cook book" statistics courses being given by self-taught statisticians.

The second alternative brings to mind the comparison which has been made between a university computing center and the university library. The Computing Department might then be regarded as analogous to the Library Science Department. Despite the size and importance of the typical university library, there are few universities where the Library Science Department has much prestige. I suspect that an even worse fate would await any Computing Department, with a rapid fall in standards following soon thereafter.

On the positive side, the Mathematics Department can offer not only prestige to the courses, but can and indeed should provide a continuous stream of interested undergraduates. Faculty members and research students who are interested in advancing the boundaries of the computing field can also be expected to come from the Mathematics Department. While computers are not solely mathematical, there is so much about them, both in respect to design as well as to use, which is essentially mathematical, that it would seem difficult to find a more appropriate department to offer the fundamental programming and coding courses.

In the event of an openly hostile mathematics faculty, the above argument may not be valid. In this case, if persuasion and demonstration will not convince the mathematicians that the computer is important to mathematics, then there is little left but to look for a more friendly home. However, I still think that such a sponsor should be another recognized department rather than a specially created one.

Graduate Level

The programming and coding courses would seem to have minor places in a graduate program. Here the concentration should be on numerical analysis and applied mathematics with appropriate pure mathematics support. The programming and coding courses, if they have not been taken as undergraduate courses, should be taken as soon as possible so that, in the subsequent graduate studies of numerical analysis and applied mathematics, the computer can play its rightful role as a major mathematical tool.

Outside of fundamental programming and coding instruction, courses involving computers can well be

given in other departments. It seems, for instance, quite appropriate that courses on the design and construction of computers be given by the Electrical Engineering Department, and courses on business data processing by the Business School. To ensure that this is indeed the case and that a course on business data processing does not in reality become a programming and coding course for business students, it would seem desirable to have some faculty committee exercising overall supervision of all courses concerned with computing. It is difficult, however, to see why more than one well-organized programming and coding course is necessary, especially if, when numbers require it, sections are set up according to the students' major fields of interest.

The second part of this note has been concerned mainly with the integration of computing courses into the mathematics curriculum. It is just as important to have similar integration in the business sequences and as options in the engineering and physical sciences. This may involve modification of existing courses or possibly the complete abandonment of a few courses. Such changes must be made if we are to keep our curricula in step with new developments such as the high speed computer.

RESEARCH APPOINTMENTS AT THE ARGONNE NATIONAL LABORATORY

The Argonne National Laboratory has announced a program of summer employment in 1959 for undergraduates, graduate students, and faculty. Undergraduate students will be selected on the basis of years of college work completed, grades, references, and experience. Applications must be filed no later than February 15, 1959. Forms and application material are available from the Employment Office, Argonne National Laboratory, P. O. Box 229-SA, Lemont, Illinois.

Appointments of graduate students may be made for summer employment or occasionally longer. In addition, appointments will be made for thesis work when the graduate student has completed all course work and passed all qualifying examinations at his university or college.

Research appointments of faculty members will ordinarily be made for summer employment or for a period of approximately one year. Applications for summer employment as graduate student or faculty member should be submitted by January 15, 1959. Applications for other appointments can be filed at any time. Further information and application forms are obtainable from the Professional Personnel Office, Argonne National Laboratory, P. O. Box 299, Lemont, Illinois.

I ACCUSE . . . .

J. M. F. VICKERS

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The absence of any desire to continue learning after the baccalaureate, as evidenced by most engineers, seems to be connected with two developments in engineering teaching of recent years. Both are correctable, but either is guaranteed to stifle any wish in the student to have further contact with education or research.

Specialization

The first problem is that of increasing specialization, with consequent reduction in the number of hours spent on a particular course, and constant splitting of the curriculum into smaller and smaller splinter groups. Under these circumstances there is a continual trend for faculty members to teach courses in which they are tolerably proficient, and to tend to become the "local expert" in the department concerned.

This can lead to a very dangerous condition with many teachers, since once acknowledged as an authority they tend to become dogmatic in their presentation, intolerant of the ideas of others in their self-chosen specialty and at times very afraid to admit a lack of knowledge on any particular point connected with their work. This must not be interpreted as a criticism of a real authority in any field, but merely of the pseudo-authority which is being spawned continually by our present specialized system.

The true authority is invariably humbled completely by the lack of knowledge in his major subject, and in particular aghast by his personal ignorance. For this reason he is essentially a stimulating teacher, since he is always prepared to share what knowledge he has with his students and to admit his limitations and the lack of information that exists in the scientific literature.

The pseudo-authority, on the other hand, is the most effective strangler of any student desire to continue learning that it is possible to devise. By assuming an air either of intolerant belligerency or, worse, of kindly tolerance, he leaves the student completely without hope. Everything is known in that particular field that it is possible to know. Professor —— knows it all anyway. It has taken him thirty years to learn it all, and finally look at the old boy now, having found it all out, what has he to live for? In one respect at least the student is correct: the old boy has nothing left to live for, since, having set himself up as an expert with a relatively small amount of knowledge, he now does not dare to read or work further in the field lest he get out of his depth.

This is particularly true of those teachers who were average students of mathematics as undergraduates, who never made any attempt to improve, and now find that, lacking knowledge of advanced mathematics, they are completely unable to read the modern technical literature in the field for which they are supposed to be the departmental experts. These people frequently bemoan their lack of time for reading and research, their heavy teaching loads and many other things, while actually they are merely hiding behind their teaching as a shield to protect them from doing anything useful in the way of reading, writing, or experimentation.

Textbook Writers

The second reason why students in general do not feel either that they wish to continue learning after graduation or, more important, that they need to do so, is the superfluity of professional textbook writers whose products are being used by the publishers to flood the market with questionable texts. The present plague is quantity without quality.

As in other fields of endeavor in the advertising world one is assailed with texts that are "absolutely and completely unique," "newer than new." Presumably one would be offered a text which covered the latest scientific discoveries of the 21st century if any of the advertising executives had managed to think of it first. This has led to the evolution of the sub-species "professional author," the typical jack of all trades, master of none.

According to one of the major publishing houses, the most widely used text in one particular field of engineering has been written by one of these professionals, who has also published a text, in more than one edition, in a totally unrelated field. If either text was stimulating there would be some excuse for this, but one must consider some of the reasons why one of the texts is used.

First, it is extremely popular with the students, for the simple reason that for every problem that the author has set there exists a formula in the appropriate chapter, into which figures may be substituted and an answer obtained with the use of no mental process beyond that of a grade-school child.

Second, it is extremely popular with a certain type of instructor, because all controversial points are ignored, omitted or glossed over with a few white lies guaranteed to make certain that no student will realize that they are interesting or important, thus insuring that no awkward points can be raised in class which might tax the abilities of the pseudo-expert.

With the aid of such a text, it is possible for both students and instructors to spend a certain number of hours per week in a state of complete coma without making the outcome of the course one whit different. At the end the student has a reasonably large amount of knowledge of the practice of his forebears, a reasonable dexterity in the handling of grade-school mathematics, and a profound conviction that he knows most of what there is to know about that subject. In addition, he has a certainty that there is nothing more worth learning in that particular branch of applied science and even the suspicion that there was nothing worth learning in the first place. Here one has the typical popular text, despised and abominated by scientists, industrialists, and researchers.

Here are royalty payments, large profits, no thought, and the chance for the representative of a publishing house to inform a doubter of the system that he is a lone voice, and that it is impossible for the majority of other university teachers in his field to be wrong. Unluckily the doubter may neglect to ask whether that majority is made up of researchers and stimulating teachers, or of pseudo-experts, who have taught the same course for thirty years without one iota of thought during one moment of that incredibly long and important time.

"During that time" the pseudo-expert will have accumulated seniority, respect and honor, together with thirty repetitions of one year's experience. He will also deserve the spoken or unspoken curses of the alumni for a betrayal which, like a delayed action bomb, did not take effect until the first important project undertaken in

industry proved that there was neither a useful formula available in the text or handbook nor any useful theory available in the head of the engineer concerned.

Faculties Could Correct

The two indictments discussed above, which stifle any wish for advanced learning, may be laid directly at the feet of engineering faculties, who could correct both by applying a reasonable amount of effort. It is necessary first, however, to decide whether the problem warrants any correction.

America is strong and has made her reputation by her manufacturing capacity and an innate ability to devise short-cuts in production. These are combined with a native drive in the average worker that tells him that he is at least as good as, if not considerably better than, the man at the next bench.

In Europe the "boss" is a creature apart, divinely ordained, on a pinnacle which is unattainable by the average workman, and therefore to be fought through the trades union. Here there are no such unattainable pinnacles. There exists a relatively direct route from bottom to top in most industries, and the man who is complaining to his union representative one day may shortly be trying to cope with a union dispute from the point of view of management.

This situation has led to a productivity which outstrips the remainder of the globe, and has led to the destruction of three major dictatorships in modern times. It has turned this nation into both the richest country and the greatest supplier of goods in history. Productivity has led to an emphasis on methods of production and quality of production in American industry, but has yielded relatively little original development.

Until the advent of World War II, this country was content to produce a few men of the calibre of Edison and Bell, but to rely on Europe for new ideas. This system worked well up to that time; Europe invented, and the U.S.A. produced. Now, however, with half of Europe behind the Iron Curtain, it is no longer safe to afford the luxury of importing magnetron tubes and jet engines in their prototype form from England.

America can no longer allow Germany to produce the first effective long-range rocket, nor rely on top-flight European scientists fleeing Europe for political reasons and settling in the U.S.A. America must have more new ideas developed by people trained in this country, in addition to being the major production center of the world.

This dual role is not a new concept. Before World War I Britain and Germany were the co-leaders in development and production in the world. This country must now assume such leadership. Therefore the cultivation in our students of the desire to continue learning after the bachelor's degree is vital to our national welfare.

Aspects of Improvement

Three major facets of engineering teaching must combine to achieve the desired result: course content, lecture presentation, and the attitude of the instructors toward their subjects. The question of what is taught is gradually being settled. The major upheaval of the past two years appears to be producing curricula in the various universities which lean more towards the basic and engineering sciences and less towards the practice of engineering.

In the four years that a student spends as an undergraduate there is sufficient time only to acquaint him thoroughly with the basic principles of the applied science which he is proposing to pursue for the remainder of

his life. The importance of the sciences is illustrated by the triumphs and, almost as important, the errors of his forefathers. Once well equipped with such basic elements, he will enter industry with an inquiring mind, capable of designing from first principles, and with a great potential as a producer of new ideas.

The problem of how the basic principles are to be taught is probably the most controversial of all. There are many texts available in all subjects, and the question of choice is vitally important. The first pitfall to avoid is the writer of many books on different subjects. What is needed is more experts writing text books, and fewer text-book-writing experts.

This particular trap also contains most of the texts with titles on the covers which are completely different from the subject matter inside. Such a book is the salvation of many poor instructors who can point to a high-sounding title on the cover of the text they use while they are still able to give an extremely low-grade course.

If the course material is taken from several textbooks, written by men who are active workers in that particular field, then the elements of a good and inspiring course are present, but not the full body. An inspiring course can be set up only by the use of more effort from the instructor than that needed by the students writing the examinations. It is vital that the instructor should at all times keep up with the technical literature in his subject. He must still be engrossed with the desire to learn. He must be completely familiar with at least three of the leading texts, in order to be able to present the finer points of the more complex sections of the course.

In this way his lectures will present many different points of view to the class, instead of merely parroting the author of the chosen text. Lectures will also point out not only what is known, but also what is not known, and how close to or far away from that knowledge man is at present.

Finally, it is always advantageous to select a text for the course which it is not possible to cover completely in the time available. At least the student is presented with the fact that more knowledge is available in the subject and that it has not been exhausted completely in a three-hour, one-semester course.

The Difficult Question

The final and most difficult question is that of the instructor's attitude. The most important quality of an inspiring teacher is humility, not knowledge or an ability to speak in public. He must at all times be willing to admit a mistake, often extremely difficult for some. Also he must be willing to admit a lack of knowledge.

This is easy if he is well read in his subject, since in general his lectures will continually point out how close the limits of knowledge really are and how much is not known by any man. Under these circumstances it becomes easier to admit lack of knowledge as an individual. It is remarkable how close even a sophomore class will be to the extreme frontiers of knowledge in many subjects.

Recognition of this, even at an early stage, can inspire a desire to learn for the rest of a student's life. The last, and most important, thing that the instructor can instill into a student is a profound suspicion of texts, accepted theories, and the normal arguments against certain courses of action or design. If the student leaves his university with the ability to question accepted theory and practice, and even his own line of reasoning, he will automatically continue to learn for the remainder of his life and at the same time will contribute original thought to his chosen profession.

PITTSBURGH, 1959 HOST FOR ASEE ANNUAL MEETING

FREDERICK E. LANGE

Director of Community Relations, University of Pittsburgh

When the members of ASEE come to Pittsburgh for the 67th annual meeting in June of 1959, they will see a new city with new civic and engineering accomplishments.

The host institutions, Carnegie Institute of Technology and the University of Pittsburgh, will show what is happening in engineering education in the heart of a city which boasts of a rennaissance in building, slum clearance, smoke abatement, and civic pride.

The work began in 1947 under the leadership of the Allegheny Conference on Community Development. This organization includes the county of Allegheny as well as the City of Pittsburgh, for most problems—like the smog—concerned "Greater Pittsburgh."

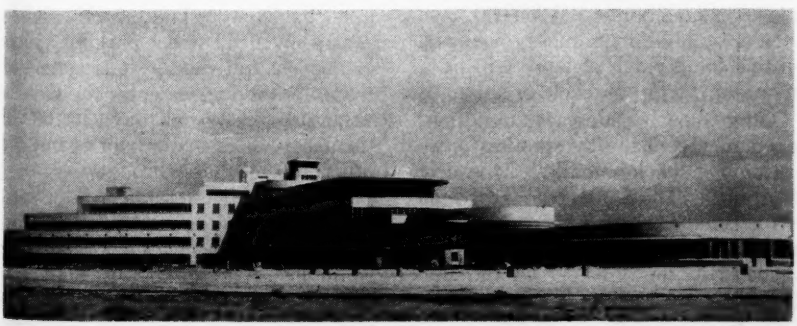
Pittsburgh smog, a pall over the city about ten years ago, was eliminated largely through the efforts of the conference. It was the first, basic step in the "saving of Pittsburgh."

There was already an anti-smog law on the books, but timid officials did not enforce it. As a result about 11 o'clock every winter morning the city was enveloped in a dark cloud of smoke and downtown lights had to be turned on just as though it were night.

The conference conducted a persistent campaign of education in the schools and gave vigorous support to Mayor David Lawrence when he decided to enforce the law.

The result is that today Pittsburgh has abated its smog nuisance by 88 per cent. And when one looks at the new downtown from the heights of Mount Washington, just across the Monongahela River, the softly colored tall buildings in their parklike settings seem clear and lovely.

Pittsburgh's down town is small, covering about a sixth of a square mile. For years it has been known as the "Golden Triangle," because it is a peninsula at the junction of the Al-



Built by Allegheny County at a cost of $33,000,000, the Greater Pittsburgh Airport is 1500 acres in size. It was opened to commercial operations in June 1952.

Located 15 miles west of the Triangle, the Airport will be easily accessible with the completion of the new Penn-Lincoln Parkway.

legheny and Monongahela Rivers, which form the Ohio. And it was called golden because so many Pittsburgh millionaires were made there in past years.

But in recent times—that is before the great rebuilding job —the golden was dropped. The area had become a commercial slum with an elevated spur railway running through it, and switch engines spewed smoke. The point had become a favorite hideout for hobos and one old warehouse was used by the city to store automobiles it had seized for parking or other violations. In the quarter century preceding the new building program no new buildings of importance had been erected in the area. A noted architect remarked incisively that it would be cheaper to abandon Pittsburgh than rebuild it.

Then came the "great renaissance," to quote still another phrase common here. Fifty-nine acres at the point of the triangle were bought or seized through condemnation. Thirty-six acres were set aside as a state park, containing the site of old Fort Pitt, and of Fort Duquesne, prominent in the annals of the French and Indian War.

The remaining 23 acres adjoining the park were zoned for office buildings. So far about $300,000,000 have been or will be spent on improvements on this small patch of land, putting it in one of the top brackets of value.

Three new "Gateway" buildings, faced in greenish-gray stainless steel, are among the landmarks of the new Pittsburgh. The State of Pennsylvania has erected a sixteen story blue aluminum office building to house all its agencies in this area. And the Bell Telephone Company is finishing another building in the Gateway.

Farther up in the Golden Triangle, between Sixth and Oliver Avenues and Smithfield Street and William Penn Place, is another showplace of the new Pittsburgh—the bright acre of Mellon Square. Three Mellon family foundations enabled the city to acquire the land by a gift of $4,300,000. Then the Pittsburgh Public Parking Authority issued bonds for $3,500,000 to build a six-level parking garage under the park.

Mellon Square has meant a lot more to the Golden Triangle than merely giving it a lovely spot of shrubs, fountains with bronze basins, all set on a flooring of burnished gray granite. It has brought the renaissance to the former site of another commercial slum. Sixteen old buildings, dating to the turn of the century or earlier, were torn down to make way for it.

Two more of Pittsburgh's distinctive skyscrapers have arisen on the periphery of the square—the 30-story Aluminum Company of America office building, and the 40-story United States Steel-Mellon National Bank building. In all, 51 new buildings have gone up in the Golden Triangle since the great rejuvenation started in 1946—in contrast to the fact that no building of any consequence had been erected there in the previous 25 years.

In such a tight little downtown as this, traffic has always been a serious problem. And it still is in spite of the fact that the Parking Authority has set up 4,000 off-street parking spaces in the last ten years. It is estimated that 300,000 persons enter the Golden Triangle every week day; 160,000 of them stay to shop or work, and the other 120,000 pass through.

To ease the parade of passers-through, enabling many to bypass, the east-west Penn-Lincoln highway is under construction. It will cross the point of the Triangle, where the two rivers meet, and have roadways leading to and from downtown. One end connects with the Pennsylvania turnpike and the other with the

Greater Pittsburgh airport, said to be the biggest in the country. The parkway will permit motorists to go through downtown at 60 miles an hour, unimpeded by traffic signals. Its average overall cost is estimated at about $6,000,000 a mile.

On the eastern fringes of the upper Triangle another pattern of improvement is emerging. Clearance of 95 acres of slum dwellings will be accomplished next year. The area will be developed as low-rent garden apartments. In its center will be the new Pittsburgh auditorium-sports arena, with seats for more than 16,000 and parking space for 3,000 cars.

These examples give some idea of what Pittsburgh is doing and how it does it.

As the urge to rebuild the city gathers momentum, there is a determination to make Pittsburgh not only a city of beauty, but to make it an intellectual as well as an industrial center. The Allegheny Conference on Community Development has been the means of securing generous gifts from foundations, individuals and corporations.

In the last six years donations have been given as follows:

$13,600,000 for a graduate school of public health at the University of Pittsburgh health center.

$15,000,000 to endow medical teaching in the University's health center.

$12,000,000 to build a health center administration building.

And $6,000,000 to found a school of industrial administration at the Carnegie Institute of Technology.

The "Golden Triangle" as it will appear when the present "Renaissance" construction program is completed.

Private foundations have given the Allegheny Conference $300,000 to build an educational television station. The station, WQED, is now in operation. And to offer Pittsburghers a chance at primitive open country, the Conference has bought and given to the state several thousand acres of forest 40 miles north of the city.

These are some of the sights ASEE members will see in 1959 in Pittsburgh.

EXPERIMENTAL PROGRAM FOR TEACHER-TRAINING INTERNSHIPS

The University of Illinois will undertake a program for the training of prospective engineering teachers under a grant from the Ford Foundation.

Five fellows in mechanical and five in electrical engineering will be named each year for three years. Each fellow will receive $2,000 per year for two years, and those with children an additional $600 per year. Tuition will also be paid.

Fellows will enroll as first-year graduate students in engineering taking one-half to two-thirds study load. As teaching interns, the fellows will receive experience in classroom and laboratory instruction under an experienced engineering teacher. The third part of their program will involve seminars in which all fellows will come together for interchange of ideas on teaching and engineering.

The aid of the teaching faculty in all engineering colleges is sought in locating prospective teachers among seniors and recent graduates. *The fellows will not be eligible for teaching positions in the University of Illinois for five years after finishing the program. The purpose of the program is not to augment the teacher supply for the host University.*

The Coordinator of the program is Professor S. Konzo, Mechanical Engineering Building, Urbana, Illinois. Inquiries concerning the internship should be sent to him. Deadline for applicants is February 15.

CANDID COMMENTS

THE FUTURE OF MACHINE DESIGN

JOSEPH MODREY

Chairman, Department of Mechanical Engineering, Union College, Schenectady, New York

Excerpted with the author's permission from a newsletter sent to members of the Machine Design and Manufacturing Subdivision of the Mechanical Engineering Division of ASEE before the Annual Meeting in Berkeley. Professor Modrey was chairman of that subdivision.

There is considerable doubt in my mind that machine design will survive the demands of the mechanical engineering curriculum five years from now unless some drastic changes take place. In too many schools the intellectual challenge of the machine design sequence is not worthy of its chronological position in the undergraduate program. Usually machine design follows on the heels of such courses as dynamics and strength of materials and in its later stages runs concurrently with fluid dynamics and heat transfer. Yet it seldom rises to the "engineering science" level of these courses. As a matter of fact, the stress analysis approach in most of the popular machine design texts is a regression compared to the rigor of the strength of materials course which precedes the design course. With the current pressure for more engineering science in mechanical engineering curriculums, the days of the machine design course as we know it now are numbered.

We might look to the graduate schools for appropriate directions of development.

Graduate courses bring into sharp focus either the vigor or vapidity of a particular segment of the curriculum. If a subject is static or unworthy of higher level development, it may not ever become a serious part of the graduate program. If, on the other hand, a course clearly meets the demands of the graduate curriculum, it obviously possesses dynamic characteristics which can percolate into the undergraduate version. In short, today's good graduate course is a preview of the shape of tomorrow's undergraduate course.

Actually deciding just what the mechanical engineering faculty should teach in the field of mechanical design is a difficult decision. In the realm of "soft mechanics" of mechanical engineering, the choice of subject matter is clear cut. Thermodynamics, heat transfer, fluid dynamics, combustion theory, etc. are mechanical engineering subjects pure and simple (some dissent from the chemical engineering faculty). But when it comes to the "hard mechanics" of mechanical engineering, the situation is somewhat clouded. Mechanical analysis includes subjects such as vibration, theory of elasticity, controls, etc., but here we often share the responsibility with departments of mechanics, physics, or electrical engineering. While from the students' point of view it does not matter whether the mechanics or mechanical engineering faculty teaches advanced vibration, it does make a difference to the health of the mechanical engineering curriculum. In the "hard mechanics" area only advanced kinematics remains exclusively in the mechanical engineering camp, but unless we develop this subject more aggressively it, too, will slip away from us.

MECHANICS DIVISION BULLETIN

EXECUTIVE COMMITTEE

P. F. Chenea, Ch..1959	A. Higdon....1960	J. O. Smith..1961
R. L. Flanders.....1959	L. A. Smith..1960	E. J. Marmo.1962
F. L. Singer.....1959	D. R. Carver.1961	E. P. Popov..1962

Secretary of the Mechanics Division: Major Vincent S. Haneman, Jr., Department of Aeronautical Engineering, Air Force Institute of Technology, Wright-Patterson AFB, Ohio.

Editor: Arthur W. Davis, Department of Theoretical and Applied Mechanics, Iowa State College, Ames, Iowa.

Chairman's Message

PAUL F. CHENEA

Professor, Electrical Engineering, Massachusetts Institute of Technology, Cambridge

At the last annual meeting of the ASEE in Berkeley the Mechanics Division membership heard a considerable amount of criticism of the current teaching of engineering mechanics. Some of this criticism, while sincere, has not been well thought out and hence it suggests certain changes which would be most undesirable. On the other hand, certain criticisms have considerable validity and importance and they suggest action which should certainly be studied further. Still other criticism is vague and seems to indicate that mechanics or mechanics instruction is not modern or up to date or something similar. The normal reaction of most of us, the teachers of mechanics, is to become exasperated at all of this recklessness directed our way and it causes us to make equally irresponsible and meaningless statements such as, "mechanics is mechanics" or "Newton's laws have not changed so why should one expect the subject matter of mechanics to change or be less true." It is clear that there are arguments on both sides but recognizing this self-evident fact does not settle the controversy. In this short message I should like to analyze some of these allegations and to examine their validity.

To put the matter in perspective it is helpful to view the subject of engineering mechanics from the viewpoint of J. L. Synge.[1] He indicates that scientific theory (like all Gaul) can be divided into three parts: (a) foundations, (b) accepted dogma and (c) excursions. The foundations are the definitions, axioms, postulates, principles or natural laws on which the whole is based. The accepted dogma consists of the deductions from the foundations which are in harmony with observation and experiment. The excursions wander away from the accepted dogma to the known boundaries of the realm of applicability of the theory and beyond. The scientific theory grows and is modified by fruitful excursions which extend the accepted dogma and by critical scrutiny of the foundations which clarifies and modifies the definitions, principles, etc.

[1] *Relativity: The Special Theory*, Interscience Publishers, Inc., New York, 1956.

At first glance there is a tendency to say that only the foundations should be taught on the grounds that a student who masters the basic fundamentals can certainly master the applications as he needs to at a later date. This is the position taken by many who criticize current mechanics instruction. I believe that this particular criticism rests upon a false premise. It is usually by dissecting a certain amount of the accepted dogma and the techniques of deduction involved that one gains an understanding of the foundations and learns how to make fruitful excursions which add to the accepted dogma. It is primarily by careful study of some of these excursions that one begins to appreciate the power and the limitations of the theory. Surely, we will all agree that understanding, ability to solve new problems and appreciation of the scope of a theory are important, even vital, educational goals.

It has been argued further that a study of the foundations alone will accomplish the above just as well or even better. Such an argument seems on the surface to be self-evident and appears to be irrefutable. However, as any one who has struggled at the foundations of a theory well knows, this is no place for the apprentice. In fact this is the most subtle part of the whole structure. The study of the foundations of a scientific theory demands a keen understanding of the theory, its accepted dogma and its excursions, which understanding the student can hardly be expected to have. Indeed, given this, he, in all probability, needs no further instruction but only time to study under his own head of steam.

A far more serious criticism than the above is the one that charges that the foundations are laid down in a haphazard and incomplete fashion and that the dogma selected as a vehicle for gaining an understanding has little current utility. There are too many cases in which engineering mechanics, as commonly taught, has proved to be a poor foundation upon which to build a knowledge of fluid dynamics, automatic control, electron ballistics and even structural dynamics and there are too many instances of courses designed to drill the student in the dogma associated with pin jointed structures, riveted joints and the shrinking of a buggy tire on a wheel, to permit us to shrug these criticisms off lightly. The fact that these allegations refer to diseases that afflict all service courses is also of little real comfort.

It is time that we reconsidered the problem of carefully and correctly presenting the principles of mechanics in a meaningful form and that we search out the accepted dogma of the age of automation and space technology for use as a vehicle in the understanding of these principles. This is a very important task for the teachers of engineering mechanics and one that is long overdue. Not until this has been done can we feel that we are truly adding our full measure to modern engineering education.

ASEE ANNUAL MEETING

PITTSBURGH, JUNE 15-19, 1959

BEWARE OF STUDENT IMPROVISATIONS

JOSEPH C. OSBORN

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Recommended for publication by the Mechanics Division. With this article we are reinstating the problems department. Most of us have met this problem or similar ones in our teaching but probably have not taken the time to analyze the problem as completely as Professor Osborn has analyzed it. His comments should be interesting to most teachers of engineering mechanics.

Most engineering students who are beginning the study of strength of materials possess a substantial aversion to setting up an integral when they are confronted with a physical problem where such a procedure is in order. To counteract this propensity, most elementary textbooks of strength of materials include some problems which presumably cannot be solved without the use of calculus. Such a problem[1] is the following:

"Determine the elongation of a uniformly tapering bar, suspended vertically, caused by a load of 10,000 lb. at the lower end. The bar is 100 in. long; the diameter of the upper end is 2 in. and of the lower end 1 in. Use $E = 30 \times 10^6$ p.s.i. and neglect the weight of the bar. Answer: 0.0212 in."

The student has previously encountered the expression: $\delta = \dfrac{PL}{AE}$ for the elongation of a bar of constant cross-section "A", but in the present situation, what should be used for the area?

(1) First trial. Perhaps the area at the mid-point will work.

$$A_1 = \frac{\pi}{4}\left(\tfrac{3}{2}\right)^2 = \frac{9\pi}{16}\ \text{in.}^2$$

and

$$\delta = \frac{10{,}000 \times 100}{9\pi/16 \times 30 \times 10^6} = \frac{16}{270\pi}$$

$$= 0.0189 \neq 0.0212\ \text{in.}$$

This obviously doesn't work, so the student will have to look further.

(2) Second trial. Perhaps the "average" (that is, the arithmetical mean) of the upper and lower areas will work.

$$\text{Area at lower end} = \frac{\pi}{4}\ \text{in.}^2,$$

$$\text{Area at upper end} = \frac{\pi}{4}(2)^2 = \pi\ \text{in.}^2,$$

$$A_2 = \frac{1}{2}\left(\frac{\pi}{4} + \pi\right) = \frac{5\pi}{8}\ \text{in.}^2$$

and

$$\delta = \frac{10{,}000 \times 100}{5\pi/8 \times 30 \times 10^6} = \frac{8}{150\pi}$$

$$= 0.0170 \neq 0.0212\ \text{in.}$$

This seems to be getting farther from the answer, and many students would consider it appropriate to give up at this point. However, a persistent and resourceful student might well continue the search for an appropriate area for the formula.

(3) Third trial. Perhaps the geometric mean of the upper and lower areas will work.

$$A_3 = \sqrt{\frac{\pi}{4} \cdot \pi} = \pi/2$$

and

$$\delta = \frac{10{,}000 \times 100}{\frac{\pi}{2} \times 30 \times 10^6} = \frac{1}{15\pi} = 0.0212\ \text{in.}$$

(correct)

The student's hour of triumph is now at hand. He has found the answer, and without the use of calculus.

Unfortunately, this procedure is cor-

[1] Problem 109, p. 8, *Elements of Strength of Materials*, Timoshenko and MacCullough.

rect not only for this problem but for a certain class of problems of this type. The applicability and the limitations of the student's procedure can be determined from the following general analysis:

Suppose that the cross-sectional area of the bar shown in Figure 1 varies according to the law: $A = Ky^n$. Then

$$d\delta = \frac{Pdy}{Ky^nE} = \frac{P}{KE}y^{-n}dy$$

and

$$\delta = \frac{P}{KE}\int_a^b y^{-n}dy = \frac{P}{KE}\left[\frac{y^{-n+1}}{1-n}\right]_a^b$$

when $n \neq 1$,

$$\delta = \frac{P}{KE(1-n)}(b^{1-n} - a^{1-n}).$$

If $n = 2$:

$$\delta = \frac{P}{KE(1-2)}\left(\frac{1}{b} - \frac{1}{a}\right) = \frac{P}{KE}\left(\frac{1}{a} - \frac{1}{b}\right),$$

$$\delta = \frac{P}{KE}\left(\frac{b-a}{ab}\right) = \frac{PL}{E(Kab)},$$

but $A_1 = Ka^2$ and $A_2 = Kb^2$; hence

$$a = \sqrt{\frac{A_1}{K}}, \quad b = \sqrt{\frac{A_2}{K}}$$

and

$$ab = \frac{\sqrt{A_1A_2}}{K}$$

or

$$Kab = \sqrt{A_1A_2}.$$

Eq. (1) $\delta = \dfrac{PL}{E\sqrt{A_1A_2}}$ for $n = 2$.

For the general case of $n > 1$:

$$\delta = \frac{P}{KE(n-1)}\left(\frac{a}{a^n} - \frac{b}{b^n}\right) = \frac{1}{n-1}\left(\frac{Pa}{Ka^nE} - \frac{Pb}{Kb^nE}\right)$$

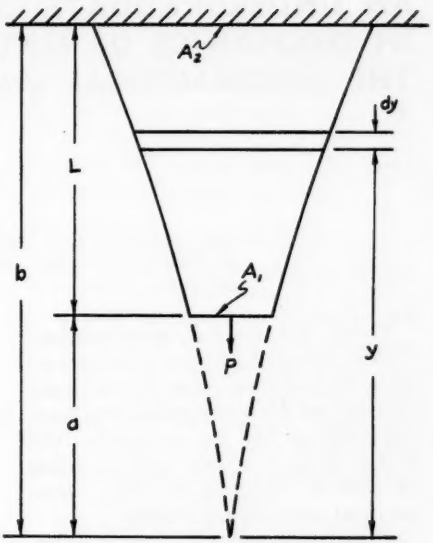

Fig. 1

but $A_1 = Ka^n$ and $A_2 = Kb^n$; therefore

$$\delta = \frac{1}{n-1}\left(\frac{Pa}{A_1E} - \frac{Pb}{A_2E}\right).$$

Eq. (2) $\delta = \dfrac{1}{n-1}(\delta_a - \delta_b), \quad n > 1,$

where δ_a = elongation of a bar of uniform area "A_1" and length "a" and loaded with a load P and δ_b = elongation of a bar of uniform area "A_2" and length "b" loaded with a load P. For the case where $n = 1$:

$$d\delta = \frac{Pdy}{KyE};$$

$$\delta = \frac{P}{KE}\int_a^b \frac{dy}{y} = \frac{P}{KE}\ln\frac{b}{a}$$

but

$$K = \frac{A_1}{a} = \frac{A_2}{b};$$

therefore

$$\frac{b}{a} = \frac{A_2}{A_1} \quad \text{and} \quad \frac{1}{K} = \frac{a}{A_1};$$

(Continued on page 365)

AN UNDERGRADUATE COURSE IN MECHANICS OF MATERIALS FOR THE AERONAUTICAL ENGINEERING STUDENT

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Presented at the June, 1958, Annual Meeting of ASEE at the University of California, Berkeley. Recommended for publication by the Mechanics Division.

There are several considerations which one must first set down before an undergraduate course in mechanics of materials for aeronautical engineering students can be analyzed. The first of these is a clear understanding of what is meant by the term "aeronautical engineering student."

Every engineering student is potentially an aeronautical engineer. One need only inspect the roles of the engineering department of an average aircraft company to verify this statement. There are, for example, large numbers of mechanical and civil engineers carrying out structural analyses side by side with aeronautical engineers trained specifically for the industry.

The aeronautical engineering graduate, as such, is distinguished from other engineers in the aircraft industry by the specific training which he has received in the peculiarities and interrelationships of aircraft design. For example, the structural civil engineer is frequently employed to do detail stress analysis of aircraft. However, the aeronautical engineer is specifically trained in the techniques of marginal structural design and such concomitant unusual analysis problems as, for example, thermal stress conditions, stress concentrations, dynamic loadings, fatigue, etc.

Likewise, the mechanical engineer is trained largely in component design, whereas the aeronautical engineer has as his background system design and interdependent structural integrity problems as typified by the design of an aileron control system which is affected by the aeroelastic deflections of the wing.

One could say, therefore, that the aeronautical engineer is distinguished by the types of rather unusual problems which he must face rather than by the techniques with which he approaches these problems.

Post-requisites

Before one can logically define an undergraduate course in any discipline it is necessary to postulate the material which is to follow. In the case of the aeronautical engineering student who is to become an aircraft structural analyst and designer at graduation, the following general attributes are desirable.

First, he should have a *thorough* knowledge of the behavior, limitations, peculiarities, and properties of a wide class of structural materials. These materials should include all of the basic metals and their alloys. In addition, the modern designer must have at his grasp a thorough understanding of ceramics, plastics, rubbers and synthetics, and he must also understand the behavior of such exotic materials as beryllium. This signifies that the aeronautical engineering graduate should be well versed in metallurgy, physical chemistry, solid

state physics, and the application of these subjects to the engineering use of materials.

Second, the aeronautical engineering structural analyst and designer should have an understanding of stress and strain states in both elastic and inelastic media. This should cover the states of stress and strain under both static and dynamic loadings whether uniform or non-uniform. Basically, of course, here one is talking about the fundamentals of elasticity and their extension to inelastic materials. One would definitely require that the undergraduate aeronautical engineer realize that stress is a tensor and be aware of the connotation of this term.

Third, the aeronautical structural analyst and designer should have a rudimentary knowledge of the exact solutions of the theory of elasticity. This is essential. Throughout design and analysis of aircraft structures, the engineer is forced to make a number of approximations, assumptions, and simplifications. This means that he must, from time to time, revert to simple theories of the mechanics of materials and to numerical and approximate techniques. He must have a basic understanding of the limitations of these simple theories and techniques else he runs the risk of applying them incorrectly. There are very few methods which can be employed to ascertain the limitations of such simple theories unless at least a rudimentary knowledge of exact solutions is available. One could argue that the simple theories could be put to the test of experiment. However, this is time consuming, expensive and certainly undesirable when exact solutions or limiting solutions are available. One should not be in the position of trading money and time for indefensible ignorance.

Thus one comes to what is probably the end goal of any sequence of courses in undergraduate engineering, the ability to apply approximations with judgement and facility. This should be the philosophy, therefore, of the last undergraduate structural analysis and design course for aeronautical engineering students.

Pre-requisites or Co-requisites

Having stated what the first course in mechanics of materials is to lead to, it is next necessary to postulate the material upon which the course is to be built. If as stated above, this first course is to be based largely on properties of materials and the fundamentals of stress, strain, and stress-strain states, then the following prerequisites seem to be a minimum.

The student should have had mathematics through ordinary differential equations. It is preferable, although not completely necessary, that he also have had an elementary knowledge of partial differential equations.

He should have been exposed to modern physics. Many material properties are only clearly understood from this view point.

The student admitted to an under graduate course in mechanics of materials should have had the usual background in engineering statics and kinetics. It should be unnecessary to repeat this subject matter except as it directly applies to the topic material at hand.

It would also be desirable to precede a mechanics and materials course with physical chemistry. It is difficult at times to work such a subject in, and yet a careful survey of most engineering programs indicates that such is entirely feasible.

The above prerequisites seem to indicate that the mechanics of materials course would be pushed far too late into the program. However, this is not the case. In the Purdue School of Aeronautical Engineering program a mechanics of materials course based

on the above prerequisites could be taught in the 5th semester. Most engineering programs could include a course based on such prerequisites not later than the 6th semester. This would then leave the last 2 or 3 semesters upon which to round out the structural analysis and design program.

Existing Courses

In designing any course there are at least three phases which one goes through. First, the general philosophical background of the course must be considered. This leads only to the haziest outline of what is to be done. Second, a fairly specific but still largely general set of topic headings can be set down. From this set of headings various subjects are deleted and additions are made as the design of the program proceeds. Finally, a selection of the exact topics on a day by day basis is made and the result is the final syllabus of the course, at least until it is taught once. In this discussion the exact selection of topics must be left to the individual expert instructor. It should be pointed out, however, that as far as the aeronautical engineering program is concerned, the selection of individual topics is of secondary importance so long as the correct basic philosophy is maintained.

A careful study was made to determine whether the course outlined below is presently in existence in any engineering department. Since it is impossible to check each institution directly, a recourse to the available textbooks was made. There is a large number of text books on mechanics of materials available; therefore only a few will be referred to here. Several of the authors are well aware of the multiplicity of such books. For example, in his preface to *Strength of Materials,* Den Hartog starts with the sentence, "No apology can logically be expected from an author who has had the temerity to add still another to the existing large collection of college textbooks on Strength of Materials and hence no apology is offered." Thus the various books that were reviewed and those few which will be referred to here are by no means inclusive. However, I am certain that most will agree they are representative. For example, in addition to Den Hartog's book, reference will be made to *Strength of Materials* by Shanley; *Strength of Materials, Part I, Elementary Theory and Problems* by Timoshenko; and *Elasticity in Engineering* by Sechler.

Professor Shanley's book deserves special attention because it is quite new and modern in scope. It is literally a compendium of the basic techniques and ideas in the mechanics of materials. In his preface, Professor Shanley, in alluding to the reasons why materials behave as they do, says, "Although it is highly desirable for design purposes to be able to reduce such phenomena to mathematical form it is not the purpose of this book merely to present formulas into which the student substitutes numbers to obtain a solution. The primary objective remains that of developing a clear physical understanding of phenomena." With all due respect and deference to the distinguished author, this writer feels that the textbook falls somewhat short of the above statement, although certainly only in a matter of degree. To the uninitiated, there is still a considerable amount of technique included. Professor Shanley was probably forced into this by the fact that most mechanics of materials courses are based upon an inadequate background on the part of the student which necessitates exclusion of such items as the use of partial differential equations and consideration of non-uniform stress states.

In his preface, Professor Timoshenko points out, "At the present time a de-

cided change is taking place in the attitude of designers toward the application of analytical methods based on the solutions of engineering problems. Designs are no longer based principally upon empirical formulas. The importance of analytical methods combined with laboratory experiments in the solution of technical problems is becoming generally accepted." Incidentally, Professor Timoshenko's book was first published in May of 1930.

Finally, Professor Sechler states in his preface, "This book attempts primarily to bring into one volume the material of most interest to the engineer who needs a broad foundation based on the fundamental theories of stress and deformation of elastic bodies under load. To this end, the first part of the book is devoted to establishing the fundamental equations and assumptions underlining the whole field of elasticity."

Since nearly everyone is familiar with these very classic and very useful books, it is unnecessary to discuss them. They are undoubtedly representative of the way that most mechanics of materials courses are organized.

The Proposed Course

What is proposed here as a basic course in the mechanics of materials is somewhat different from courses typified by the books noted. For example, in a three semester hour course, it is suggested that there should be just two main topics: one, engineering materials, and two, the basic nature of stress and strain. The time in the semester would be approximately equally divided between these two subjects.

In the discussion of engineering materials there should initially be considerable emphasis on the empirical behavior of elastic and inelastic materials. Factors which influence ultimate strength, ductility, homogeneity, isotropy, etc. should be discussed at length and then available theories of failure, creep, and fatigue which rely upon these notions could be discussed. This would lead to an introduction to the synthesis of materials having various desired properties.

It is quite obvious that such material requires a fundamental understanding by the student of physical chemistry and solid state physics, hence the pre-requisites mentioned above. The student can not be expected to make sensible design judgments on the use of materials until he has at least the background represented by this subject matter.

The second part of the course would deal with the basic nature of stress and strain. It would be desirable to derive the equilibrium conditions within the body under both uniform and non-uniform stress conditions. This of course requires the use of partial derivatives and partial differential equations. It does not, however, require an extensive knowledge of the solution of partial differential equations. At this stage the student would be carefully instructed in the tensorial character of stress and all that this term implies.

Next, the notions of strain both under uniform and non-uniform conditions could be discussed. This leads to the compatibility relations for the case of an elastic body.

Finally, a careful and detailed discussion of stress-strain relations for elastic, inelastic, plastic, etc. engineering materials and the resulting governing mathematical statements would be carried out. It is at this point that the student's knowledge of engineering materials would first be put to use.

Throughout the above course it would be desirable to emphasize and freely utilize the unity of the basic mechanics of materials problems.

After all, stress is stress and strain is strain and the various applications do not require alteration of the basic nature of these ideas. In being led from one type of problem in structural analysis to another, the student should be made constantly aware of this unity. In addition, the student should be forced to assemble and put to use the appropriate mathematical disciplines. There is no logical reason, for example, to bypass the use of partial derivatives and partial differential equations. Mathematics is a tool which makes the problems of engineering easier. Therefore these tools should be exploited to the utmost. One does not saw a 2 by 4 with a hand saw if a power saw is immediately available. Courses which willfully ignore the short cuts which can be employed with the use of advanced mathematics short change the student drastically.

In such a course it would be desirable to minimize the emphasis on problem solving techniques. Where necessary, such technique can be communicated through homework problems. The problem solving techniques should come later, after the fundamentals of the subject matter are well in hand. It would also be desirable to minimize isolated analysis techniques which likewise will come later.

Follow Up Courses

It would be logical to follow the course in mechanics of materials for aeronautical engineering students by a course in applied elasticity. In such a course, the various exact solutions available from the theory of elasticity would be discussed and exploited. In particular, those exact solutions which are available for the analysis of beams, torsion of sections, plates, shells, structures under combined loadings, etc. should be discussed. At each stage of the game, possible simplifications should be pointed out and should be driven home forcibly by the use of homework assignments. It is unnecessary at this point, however, to spend a great deal of instructional time on the simplified forms on such exact solutions.

Then in the final course, various techniques such as energy methods, approximations, and computer applications, etc., which are of such tremendous use to the modern structural engineer, should be fully and adequately demonstrated. The student should be given a great deal of practice with such techniques. Furthermore, it is important that these techniques be applied to modern examples, such as low aspect ratio wings, thermal stress analysis, etc. Having had the fundamentals in the preceding two courses, the student will be in a position to exploit the approximate techniques and to realize their limitations. This latter fact can not be over-emphasized.

Summary

In summarizing the discussion of the design of a mechanics of materials course to meet the needs of an undergraduate aeronautical engineer, the following main ideas deserve emphasis.

1. A mechanics of materials course for undergraduate students should be postponed until the basic mathematics, physics, mechanics, and chemistry prerequisites are met, even though these prerequisites are somewhat advanced in that the mathematics should include differential equations, the physics should include modern physics, and at least physical chemistry should be taken. Such a mechanics of materials course can still be taught either in the 5th or 6th semester and thus allow two or three semesters for the follow-up courses.

2. The desirable course then should emphasize the properties of materials

and the fundamentals of stress, strain, and stress-strain concepts. In teaching these ideas the appropriate mathematics should be utilized to the fullest extent.

3. In the course in mechanics of materials for aeronautical engineering students it is desirable to de-emphasize problem solving techniques and to avoid all symptoms of cook-bookishness. The problem solving technique should be reserved for the last course.

4. Following the mechanics of materials course would be a first course in aircraft structural analysis, which is primarily applied elasticity and which would deal with the exact notions from the theory of elasticity; and finally a course in the techniques of structural analysis and design based on modern examples would be given.

With such a structural analysis background, a graduate of an aeronautical engineering curriculum would be in an admirable position to attack the many and varied problems which he must face in the design of modern aircraft and which are not included in any existing strength of materials or structural analysis book.

BEWARE OF STUDENT IMPROVISATIONS

(*Continued from page 359*)

hence

$$b = a\left(\frac{A_2}{A_1}\right).$$

Since

$$L = b - a = a\left(\frac{A_2}{A_1} - 1\right) = a\left(\frac{A_2 - A_1}{A_1}\right),$$

therefore

$$a = L\frac{A_1}{A_2 - A_1}$$

and

$$\delta = \frac{Pa}{A_1E}\ln\frac{A_2}{A_1} = \frac{PLA_1}{A_1E(A_2 - A_1)}\ln\frac{A_2}{A_1}.$$

Eq. (3) $$\delta = \frac{PL}{(A_2 - A_1)E}\ln\frac{A_2}{A_1}, \quad n = 1.$$

Those students who tried either the first or second method will now ask their teacher, "Why doesn't this work?" The rare student who tried the third method will undoubtedly be chagrined if his teacher does not consider his solution valid and will probably ask, "What's wrong with this method? I obtained the answer." Either question is a snare and a trap for the teacher and, in order to retain or obtain the student's admiration, he may succumb to the temptation to answer the question, "Why not?" If he does so, he has not only gone beyond the call of duty, but he may have reinforced the student's belief that the question, "Why not?" is appropriate. This question implies that a computational procedure is innocent of error until it is proven guilty, and hence that the burden of disproving a procedure rests with those who are not convinced of its validity. The correct approach is just the reverse. A person who advocates a particular procedure is obligated to justify the method by demonstrating that it follows logically from previously established principles.

In conclusion, I hope that the three cases cited above, and the corresponding expressions for elongation will not subsequently appear in text-books of strength of materials, since students would regard them as merely additional formulae to be memorized. Rather, engineering teachers should continue to insist that students should practice the application of the method which leads to the results obtained above. It is the intellectual discipline which is important, since it has a wide range of applicability.

AN UNDERGRADUATE COURSE IN MECHANICS OF MATERIALS FOR THE ELECTRICAL ENGINEERING STUDENT

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Presented at the June, 1958, Annual Meeting of ASEE, at the University of California, Berkeley. Recommended for publication by the Mechanics Division.

The solution of an engineering problem quite often involves the solution or at least the understanding of a materials problem. This is obvious, but it is important for this discussion because it refers to electrical engineering as much today as in the past; the limitations imposed by materials are still present for the electrical and electronic engineer as well as for the civil, mechanical, or metallurgical engineer. However, because of the generality of this statement, it is of little help in the selection of the proper subject matter for college courses. It certainly means that electrical engineers should have some courses in mechanics and materials; it probably does not mean that these courses should be the same as those taken by other engineers.

I propose to look into the meaning of the materials problem for the electrical engineer, to investigate his needs in the areas of mechanics and of materials, and then attempt to translate these needs into an educational program.

From the beginning of my preparation for this discussion it was evident that I could not discuss mechanics, or materials, or strength of materials out of the context of a complete program in materials for electrical engineers, and that such a program encompasses more than is now found in traditional courses with these names. Therefore, my discussion will have to refer to a complete program and later I will suggest one for your consideration.

To attempt to list the actual needs of today's electrical engineer for a knowledge of materials and materials properties is a bit dangerous because of the lack of real evidence and the differences of opinion on this point. There is certainly a feeling among electrical engineering educators that their product is less concerned with mechanical and structural design now than he was ten to fifteen years ago. This feeling is undoubtedly correct. The majority of electrical engineers graduating today are not directly, if at all, concerned with such tasks as mechanical design of machines, of transmission line towers, or of antenna structures. The few electrical engineers with such problems are backed up by mechanicals and civils who not only help with the structural design but are available for the problems of heat transfer, fluid flow, etc. It is easy to grant very much of this argument and, perhaps, to go further, but it is also true that electrical enginers require a greater awareness of materials and their limitations today than ever before.

There are a number of reasons for this. Let me try out a few on you. The first is that to a larger degree than other engineers, electricals are becoming systems engineers. Consider the history of servo mechanisms as one

bit of evidence to support this contention; or, look at the number of electricals now involved in the design of automatic control systems. For another illustration think of the number of electrical components and, incidentally, the number of materials problems, involved in a complex computer, which is nothing more than a complex system; electrical engineers have been and are prominent in computer development. Think for a moment about the nation's highly developed communications systems in radio, television, and telephone and their associated materials problems. The electrical engineer is again involved. Yes, it may be true that the modern electrical engineer engaged in the design or operation of one of these systems does not have occasion to design a beam or a machine member for a given strength, but it is also true that he must in a larger overall sense have an awareness of the limitations and uses of materials. After all, in a mechanical servo it may be a strength property which limits the speed of response, and in computers and communications systems it may be the spring on a relay, the design of a support for a tube element, or the statistical reliability of hundreds of parts in series which form the materials problems. The success of the system ultimately depends on the solutions of these materials problems.

In this relatively recent concept of the systems engineer there is a signpost for curriculum designers, a signpost which has always been applicable to all fields of engineering but which has now been brought to sharper focus than ever before. The systems engineer must bring a breadth of knowledge and a wide mastery of techniques to bear on his problems. The materials problem is not the only one he must solve or understand; there are others as important. This breadth of knowledge means breadth of understanding and it must not be accompanied by a lack of depth. "A contradiction!" I hear you saying, but I assure you that it is not.

This expanded requirement for breadth has already caused a reappraisal and a renovation of electrical engineering curricula in many of the better schools. The ballots are not all in, and, as you can suspect, there is not agreement. But without counting the votes it is clear that training in the materials area for electrical engineers must also change to meet the new challenges.

Now to another and different reason for the electrical engineer's increased dependence on a knowledge and understanding of materials and materials properties. This is a plea for a training in depth. Perhaps an example will help make the point. For all but recent graduates the theory of electrical conduction was a simple one. A few comments on free electrons and some simple electric field ideas were sufficient to explain conduction. A material was either a conductor or an insulator—its resistivity was high or low—10^{-6} or 10^{+12}. Try to explain a semi-conductor on this basis. Semi-conductors and transistors now demand a more fundamental understanding of the process of conduction so that the many new uses of such solid state devices can be exploited and their limitations fully understood. Another example: a switch was once a mechanical device —now some switches have no moving parts; they may be a solid state diode, a transistor or magnetic device employing the new square loop materials and their functions may be very temperature or humidity sensitive. These advances and others require a deeper and different and more fundamental understanding of materials by today's electrical engineer, and these facts also

call for a serious look at our educational programs in this area.

Yet, the electrical engineer continues to live and work in a world of structures. Perhaps I might digress here to relate a slightly humorous story which may bring this point home. It concerns one of my doctoral candidates who was building some apparatus to make rough checks on a mathematically complicated electromagnetic field problem he had just completed. It was necessary for him to build some supports for a rather long probe which was to be used to measure electric and magnetic fields. It was important for this support to be firm but the requirments for precision were not very exacting. He finally decided to build this device by inserting two "two by fours," 5 to 6 feet long, into a large mass of concrete—about three cubic feet or so. He thought it would be rather easy to build this in the lab, load it into his car and take it to an outdoor site where the measurements were to be made. He had no idea or, at least, did not consider how much the concrete would weigh. He gave even less thought to the poor rigidity of the "two by fours" at the position he wished to attach the long probe. Admittedly this man was rather naive about structures of this type, but let me assure you, he has a deep understanding of the science of materials. I suppose you might say he lacked the "engineering of materials!" He certainly failed to consider the limitations imposed by his choice of materials and method of construction even though the structure he needed played only a minor role in his experiment.

Let me try to summarize some of the points I have been making. First, today's electrical engineer must have a more fundamental understanding of materials and of the properties of materials than formerly required of him. He needs to understand the new circuit elements and components which have been placed at his disposal. Secondly, he must have an overall "systems-concept" of the limitations of materials in contrast to the former narrow structural concept and with this he must have breadth of learning and a breadth of ability. Finally, while the electrical engineer may not have to solve structural problems, he cannot avoid them completely. The world of engineering is, after all, a world of structures.

The educational problem here is an imposing one and we need some help. I think we can get it by backing off to take a look at the role and function of engineering education. One consoling thought should not be forgotten here. The goals which have been set are ultimate goals which do not have to be met at the end of a four or five year period. The years after college when the engineer must continue to learn can be the time of some of this educational program provided the foundation of underlying principles and the framework of applicability are firmly established during the undergraduate years. This means that whatever subject matter is chosen it must be basic in the sense that the student can build on it either in later courses or after graduation, and it must have reasonably immediate applicability to the solution of college level engineering problems so that the student recognizes its importance and returns to it as a beginning point for further study and for the solution of subsequent engineering problems. Breadth of learning implies wide use of learning, and this can only come through the thoughtful application of principles to engineering problem situations.

In mechanics of materials these ideas may lead us immediately to omit the more empirical or very special re-

lationships and lead to concentration on the minimum number of root concepts with careful application to a few cases. By basic or root, I do not necessarily mean the most fundamental or quantitative and analytical. I simply mean the presentation of basic ideas which will permit without undue handicap further growth in two directions: a) toward a later more fundamental understanding of the idea or principle, if this is eventually necessary, and b) toward the use of this idea in application or in the further acquisition of other basic knowledge. An illustration here might help to clarify a point. We start our study of physics with Newton's Laws of Motion, even though we know these have been replaced by more fundamental notions. Newton's Laws have ease of understanding and wide applicability; they contain almost no content which must be unlearned when a more fundamental study is required. Another way of saying this is that what is basic—to a student—is more a function of his level and the use he makes of the knowledge than it is of the subject matter itself.

By careful application I do not mean repeated routine use of special methods in the solution of highly idealized problems. I mean problems where choice of principle, method of execution and responsibility for the correctness belong to the student.

Now, to some details. It is clear that a program in the science of materials is necessary for the electrical engineer. This program has already received much attention,[1, 2] and I will not dwell on it except to suggest that it can begin in freshman chemistry, continue in regular physics courses and require, at most, one or two courses beyond this point. The role of the mechanics teacher in this area is not well-defined. I can suggest that in materials laboratory courses given by some mechanics departments and civil engineering departments there exist opportunities for integration and discussion of the solid state aspects of materials properties. Admittedly these discussions must be descriptive and qualitative because of the present shortcomings of solid state theory, but the important connections, and the possible future important connections, between the science and the engineering of materials can be established. The Civil Engineering Department at Carnegie Tech is presently working on an experimental course in this area. Incidentally, laboratory courses with an experimental approach to the study of mechanics of materials appear to me to be very suitable for producing awareness of structural problems.

For the "engineering of materials" electrical engineering education looks to the teachers of mechanics, and from it they expect some breadth of knowledge, wide mastery of method, and perhaps, through laboratory courses as I have just mentioned, an awareness of structures. The *Evaluation Follow-Up Report* of the Committee on Mechanics of Solids states that "Engineering Mechanics is one of the first subjects in the curriculum which offers an opportunity to develop the skill of the student in engineering methodology." The report also says that "The heart of a treatment of Engineering Mechanics is Newton's Laws of Motion or equivalent statements, which can usually be stated in very brief form. The remainder of the course is not a question of more subject matter but rather a question of

[1] Objectives in Solid-State Physics for Electrical Engineers by E. M. Williams, presented at the Joint Conference of Physics and Electrical Engineering Divisions, ASEE Convention, June 18, 1957.

[2] *The Science of Engineering Materials*, a book, edited by J. E. Goldman, John Wiley and Sons, Inc., 1957.

developing a better understanding of these laws and skill in their use in solving engineering problems." This is what I have been saying, so that it looks as though we electrical engineers have come to the right store. This is exactly what we want! I would raise a question though. Are we getting the merchandise as advertised?

In statics there is much routine and repetition that can be avoided. Repeated application of equilibrium conditions to structure after structure is certainly unnecessary, and prolonged calculation of moments and products of inertia long before their usefulness has been established is extravagantly bad education. From experience with courses in engineering analysis taught to electrical engineering students after they have taken mechanics, it is clear that such activities can be drastically pruned without serious damage. Enough pruning can be accomplished so that an elementary analysis of stress and strain can be included in a first course in mechanics and thus, the first ideas of strength of materials can be introduced. Some efforts have been made in this direction at my school, and electrical engineers now take a single three hour course of this type plus a more traditional course in dynamics. Much of what I have said about statics and strength of materials applies also to dynamics, where considerable reduction of special content could profitably take place. I am really asking whether teachers in mechanics are teaching in the spirit of the statements I have quoted from the *Evaluation Follow-Up Report*, that is, teaching from a minimum of basic principles. One wonders when the chapter headings in a mechanics text read Statics of Particles, Forces in a Plane, Forces in Space, Statics of Rigid Bodies in Two Dimensions, Statics of Bodies in Three Dimenesions, Centroids, Center of Gravity, Moments of Inertia, Method of Virtual Work, Kinematics of Particles, Kinetics of Particles: Work and Energy, Kinetics of Particles: Impulse and Momentum, Kinetics of Rigid Bodies: Work and Energy, Kinetics of Rigid Bodies: Impulse and Momentum, Columns and Curved Beams, Statically Indeterminate Beams, Deflection of Beams, Stresses in Symmetrical Beams, Local and Lateral Bucking, etc. I have purposely made the list long. I doubt if such a list for electrical engineering can be made. Let me try: Kirchkoff's Voltage Laws for one loop circuits, Kirchoff's Voltage Laws for circuits without resistance, without inductance, without capacitance; Kirchkoff's Current Laws for all these cases; Kinetics of Circuits: Work and Energy, Kinetics of Circuits: Voltage-Time and Flux Linkages. Actually I was wrong. This list could be extended indefinitely but if electrical engineering were taught this way it would be disastrous. Special cases would have replaced principles and the special cases can be multiplied and multiplied, until they equal in number the different problems to be solved. I submit that something of this nature has happened in mechanics. Beautifully simple principles of wide applicability have been replaced by complicated statements of restricted use. You asked me for the needs of the electrical engineer in a course in mechanics of materials. I make only this plea—whatever the subject matter, choose it for its simplicity and its wide usefulness.

Know Your ASEE Officers

DEAN C. L. ECKEL

C. L. Eckel, ASEE Vice President for Sections—West, is Dean of the College of Engineering and Professor of Civil Engineering at the University of Colorado in Boulder. He has been a member of ASEE since 1914, and was a member of the Council from 1934 to 1937. His joining the Society corresponds with his acceptance of an instructorship in civil engineering at the University of Colorado.

Dean Eckel's career in engineering education was interrupted by World War I, in which he served as a first lieutenant and later a captain in the army engineering corps. For a time he commanded the First Battalion, 115th Engineers at the front in France.

He returned to the University of Colorado in 1919 as Assistant Professor of Civil Engineering but went the same year to the University of Pennsylvania as an assistant professor, where he was in charge of structural design and structural engineering courses.

In 1923 Professor Eckel returned to the University of Colorado as a full professor, and in 1926 he was made head of the Department of Civil Engineering. He was made Dean of the College of Engineering in 1943.

Throughout his career Dean Eckel has supplemented his educational experience with consulting work and with summer work with various engineering firms.

Since 1936 he has also been Consulting Engineer for the Construction Department at the University of Colorado. In this position he has been concerned with structural design and the preparation of structural plans for the auditorium of the University's medical school in Denver, and the field house, a men's dormitory, wings of the liberal arts building, the new engineering building, the library, and other buildings on the campus at Boulder.

Besides ASEE, Dean Eckel is a member of a long list of professional and civic organizations, including ASCE, ASME, the National Society of Professional Engineers, the American Concrete Institute, and many others. He has been a member of the Colorado State Board of Examiners for Engineers and Land Surveyors, and he served as National President of the National Council of State Boards of Engineering Examiners in 1950–51.

DEAN ELMER C. EASTON

Dr. Elmer C. Easton, Vice President for Divisions, was born in Newark, N. J., and was graduated from Barringer High School in that city. He received a Bachelor of Science degree in Electrical Engineering from Lehigh University in 1931, and two years later he received a Master of Science degree from the same institution. Harvard University awarded him a Doctor of Science degree in 1942.

From 1931–33 Dr. Easton held a research fellowship at Lehigh University. He was a member of the faculty at the Newark College of Engineering from 1935–42, and a member of the faculty at the Graduate School of Engineering, Harvard, from 1942 to 1948. Assistant dean at Harvard from 1946–48, he came to the Rutgers College of Engineering as dean and professor of electrical engineering in 1948.

Dean Easton has been a member of ASEE since 1946 and is a member of the Executive Council. He is a member of the American Institute of Electrical Engineers, the National Society of Professional Engineers (president of Raritan Valley Chapter), the Harvard Engineering Society, the Rutgers Engineering Society and the Rutgers Club. He is also a fellow of the American Association for the Advancement of Science, chairman of the Middlesex County Planning Board and vice-chairman of the Piscataway Township Sewerage Authority. He is a member of the Advisory Board of the Pre-College Science Center, Windsor, Conn., a member of the Board of Visitors of the U. S. Army Signal School, a consultant for the World Book Encyclopedia, and a consultant for the Funk and Wagnell's Encyclopedia.

He holds membership in the following honor societies: Phi Beta Kappa, Tau Beta Pi, Sigma Xi, Eta Kappa Nu and the Blake Society.

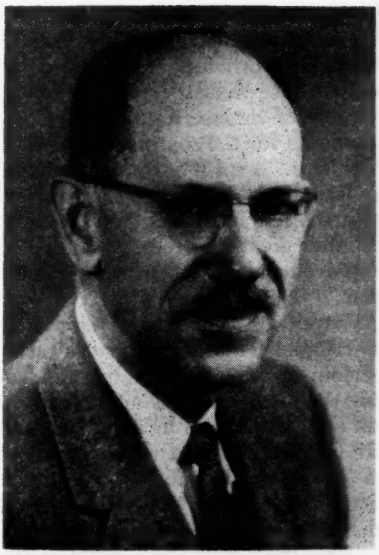
A registered professional engineer in New Jersey and Massachusetts and a part-time consulting engineer, Dean Easton is the author of *Elements of Electrical Engineering* and *Calculus Laboratory Manual*, and has contributed numerous articles to professional journals.

DEAN KURT F. WENDT

Kurt F. Wendt, ASEE Vice President for the Engineering College Research Council, Dean of Engineering at the University of Wisconsin, and Director of the Wisconsin Engineering Experiment Station, has been a member of the Society since 1927. Among his other services to the Society, he was a member of the Executive Council for 1952–54.

Dean Wendt joined ASEE the same year he graduated from the University of Wisconsin in civil engineering and began his teaching career there. When he graduated, he tied for first place honors in his class. He has remained at Wisconsin since that time, serving as head of the Materials Testing Laboratory for twelve years, then as Associate Director of the Engineering Experiment Station, and finally, in 1953, becoming Dean of the College of Engineering and Director of the Engineering Experiment Station.

In his service to the profession of engineering, Dean Wendt is an Associate on the Highway Research Board and chairman of its Concrete Division. He is also chairman of the Wisconsin Registration Board of Architects and Professional Engineers. He is a member of Tau Beta Pi, Chi Epsilon, Sigma Xi, the Wisconsin Society of Professional Engineers, the National Society of Professional Engineers, the American Society for Testing Materials, the Society for Experimental Stress Analysis, and the Milwaukee Engineering Society.



Dean Wendt has done considerable consulting work for the U. S. Forest Products Laboratory and in industry. During World War II he was in charge of the expansion of facilities for work in timber mechanics at the Forest Products Laboratory. Other work with federal agencies includes service as chairman of the Engineering Panel of the National Science Foundation.

(*Continued on page 384*)

FOR FEBRUARY—A SPECIAL ISSUE ON NUCLEAR ENGINEERING

REPORT OF COMMITTEE ON ASEE STRUCTURE JUNE 1958

Introduction

ASEE was conceived as an organization for the promotion of engineering education and for many years it functioned primarily as a device to assist in the exchange of ideas among teachers of engineering and as a clearing house for the solution of common problems. A spirit of cooperation and of friendly helpfulness has prevaded its activities, and the Society has contributed greatly to the stimulation of improvement in engineering education.

Fifty years ago, fifteen years after its founding, the Society had a membership of only a few hundred. Today the membership is approximately ten thousand. This increase is a tribute to the interest of the members in the program. The Society was organized along simple and direct lines closely related to curricular activities. In 1908 the organization chart of the society showed divisions and a few committees. The intervening half century has brought many changes to engineering education. Specialization together with an expressed need for generalization, the increase in numbers of students, the marked expansion of graduate work, accreditation, federal legislation related to education and technological advances have all influenced Society activities. However, until 1946 the response to these factors was one of adding committees in areas where needs became evident. If the committee activities prospered, and gave evidence of being of service to a segment of the membership, the committees were given division status. Thus, the number of divisions has increased through the years and more standing committees have been evolved.

In 1946, when the name of the organization was changed, some reorganization was effected. The activities of the institutional members as related to administrative problems were brought together in the Engineering College Administrative Council and a few months later the activities as related to research were coordinated in the Engineering College Research Council.

Thus, the current organization involves three councils—ECAC, ECRC and the General Council. The activities of the individual members come under the latter, which is composed of divisional representatives and national officers.

In view of the fact that the addition of Divisions and Committees has taken place on the basis of requests from small groups of individuals without reference to an overall plan, and that the scheduling of meetings of the various groups at the Annual Meeting has presented serious problems, the questions of effective organization of divisions and committees has been raised.

At the meeting of the Executive Board in April 1958, President Lindvall appointed a committee consisting of the two incumbent and one incoming Vice Presidents of Divisional activities—to make a preliminary study of the divisional and committee structure of the Society.

A brief statement of the objectives of the society, its functioning, and the nature of the divisions is appropriate as the first step in considering the problem.

Objectives of ASEE

In general terms, ASEE has a number of objectives; in the current con-

stitution eight areas of service are listed specifically. Of these, three are of particular importance in this study. These are (1) to improve the teaching and learning of engineering, (2) to improve engineering curricula and (3) to improve the professional standing of engineering education.

The first objective is of concern to every engineering educator from newly appointed teaching assistants to the presidents of universities and institutes of technology. It was to further this objective that the Society was organized and to which much attention has been devoted. The Society has a responsibility to its members to do all that is possible to improve the teaching and learning atmosphere in engineering classrooms and laboratories. It has the responsibility of so organizing its activities that it can reach every member with ideas and accomplishments that will stimulate and maintain a high level of classroom performance.

The second objective, that of improving engineering curricula, is of long standing in the society. While it is not necessarily of direct concern to the entire membership of ASEE it is the principal concern of some segments of the Society. Here again, the organization of divisions and committees should be such that the most effective implementation of curricular improvements will result.

Activities related to the improvement of the professional standing of engineering education have become a significant part of Society planning and represent a segment in which each member has an important part.

Functioning of ASEE

The society, composed of members, functions through those members in fulfilling the objectives of the Society. The lines of communication from members to the Society and thence back to the individual members are three-fold. Ideas originated by individual members may be communicated to other members through (1) division meetings at the Annual meeting or at meetings of Sections or Branches, (2) the JOURNAL or divisional publications, and (3) participation in division or committee activities apart from Society meetings.

It is estimated that less than twenty-five per cent of the membership participates in Society meetings. The attendance of members at the Annual meeting is usually less than twenty per cent of the total membership and those individuals make up a substantial portion of the attendance at regional meetings. Thus, regularly scheduled meetings are not particularly successful in reaching the membership directly, but they are extremely important in the furtherance of Society objectives. Every effort should be devoted to make the activities at the regular meetings as meaningful and effective as possible. Each member who experiences stimulation at an ASEE meeting will communicate some of his experience to colleagues who were unable to attend.

Theoretically every member is reached by Society publications. A limited sampling of the extent to which the JOURNAL is read indicates that articles in an individual's field of special interest are read regularly. With the special reader appeal of publications of individual divisions it may be assumed that over ninety per cent of the members are reached by regular Society publications to at least some degree.

A relatively small percentage of the membership participates in special committee assignments, but the results of the committee activities usually are made available to the membership through reports at meetings, through the JOURNAL and through special pub-

lications. Reports such as that of the Evaluation Committee are widely read.

Thus, active and passive participation in Society activities is available to the entire membership. The problem is one of optimizing the stimulation and effectiveness of the participation in achieving the objectives outlined.

In approaching the problem of optimization as a function of Society organization, it appears reasonable to assume that the Annual Meeting is the line of communication most affected by organization. The JOURNAL could function equally well with or without divisions, committees or other groups provided that the quality of articles submitted was unchanged. Special committee activities are now carried on outside of divisional lines.

Divisions

There are two reasons for the existence of Divisions. One reason pertains to special interests, the other pertains to having a group of workable size.

Engineering education is a complex and varied subject, with the result that specialization to some degree at least is mandatory before progress can be made. An instructor whose primary interest is in teaching thermodynamics as well as possible is not going to travel several hundred miles to listen to papers and discussions on engineering economy, even though he might read the papers when they were published. Thus, divisions developed around particular areas of interest have a strong appeal to the membership. Some of these divisions represent curricula, some represent subject matter and some represent types of organization or instruction.

Nine divisions are organized primarily along curricular lines. These are Aeronautical, Agricultural, Architectural, Chemical, Civil, Electrical, Industrial, Mechanical, and Mineral. There is variety in organization within the divisions, with Civil Engineering being one of the more complex. The Civil Engineering Division, for example, has a number of committees which function almost as individual divisions. Observation at meetings of many of the curricular divisions and study of the programs of the divisions indicates that the interest is generally directed along subject matter lines. The impression is given that the organization of the programs and the discussions in meetings largely pertain to the teaching of specific courses. The attainment of the first general objective, that of improvement of teaching, ranks high in the minds of individual members. This observation suggests that the members come together in a meeting not primarily because of curricular problems but because of similarity of subject matter problems within a given curriculum.

Seven divisions are organized primarily along subject matter lines so far as engineering education is concerned. Drawing, Economy, English, Humanistic-Social, Mathematics, Mechanics and Physics represent subject matter areas, although Mechanics may have a curricular standing in some engineering schools and others of the group have curricular standing in other colleges of the university. In general, each of these divisions, like each of the curricular divisions, represents a teaching department in the university. In contrast with the curricular divisions, none of the subject matter divisions has a counterpart among the national professional engineering societies. This fact is important in evaluating the activities of the divisions in this group. For the Engineering Drawing Division, ASEE represents their national professional society, and this is reflected in the

strength, vigor and enthusiasm of the Division.

Six of the divisions are organized on the basis of types of organization or instruction, and include Cooperative Education, Educational Methods, Evening Education, Graduate Studies, Relations with Industry, and Technical Institutes. This group constitutes the so-called general divisions. These divisions cut across curricular and subject matter areas to deal with special problems common to many facets of engineering education.

The three types of divisions have developed in part to meet special needs, in part along traditional curricular lines and in part as a means of subdividing to increase the opportunity for participation in specialized activities of particular interest to groups of individuals. It must be recognized that in some instances the divisions represent the equivalent of a national professional society in the particular field.

Size of Participating Groups

For activities other than those directly associated with the Annual Meeting and some Section Meetings, the size of a division has relatively little influence upon its effectiveness within rather broad limits. The interest, vigor and enthusiasm of the divisional officers is a more significant factor. At the Annual Meeting, the size of the division plays an important part in its scheduling and this in turn affects greatly the effectiveness of its program.

Aside from visiting, renewing old friendships and meeting new people in a semi-professional vein, the members attend ASEE meetings for three purposes: (1) to transact business with individuals, (2) to participate in sessions and (3) to learn about new developments in the field.

The first purpose is achieved in groups of two, three or four as opportunity affords and is not related directly to Society structure. The third purpose may be accomplished in large groups or small groups equally well so long as the individual participates passively only.

Thus, it would appear that the principal factor affecting divisional organization is the one associated with the opportunities for the individual member to participate actively in the Annual Meeting. Here, the size of the group is important. If the group is too small the discussion usually reverts to the details of how my 3-credit course for 12 weeks differs from your 2-credit course for 18 weeks using the same text. A limited amount of this detail is valuable to new instructors but generally it is more profitably discussed privately. On the other hand, if the group is too large, good ideas may not be presented because of lack of opportunity or because of timidity.

On the basis of extensive observation it appears that groups of between thirty and fifty interested individuals are the optimum for individual participation in discussion of papers. If only half of those in attendance are really interested, the size of the group may be doubled without unduly limiting discussion.

Rigid adherence to the principle that every member should have the opportunity to participate each day in meetings would require twenty-five or thirty simultaneous sessions for the usual number registering. This could create some scheduling problems, so the reasonable alternative is to construct the Annual Meeting program partly of sessions of this type and partly of larger group sessions, such as the present general sessions. The latter may be utilized for problems and topics of general interest, while the smaller sessions may be devoted to topics of more limited interest. This is essentially the present arrangement.

Conclusion

On the basis of the points discussed it is concluded that the divisional structure of the society has its principal influence on the organization of the Annual Meeting, which in turn has a marked influence on Society progress, both through stimulation of those in attendance and through generating papers which are made available to the members. To obtain maximum individual participation at the Annual Meeting is one goal of organizational structure.

Recommendations

It is recommended that further study be given the problem by an *ad hoc* committee, particularly to inquire whether the curricular divisions could function more effectively as subject matter divisions in the interest of reducing overlap and implementing more cross fertilization of ideas. The possibility of organizing the Annual Meeting programs around subject matter and national professional problems and utilizing the Section meetings for curricular and regional professional problems should be explored. Organization of the Annual Meeting programs on a subject matter basis would expedite arrangements for joint sessions and would help bring together members from various divisions. It may also be desirable to utilize the Education committees of the various national professional societies as vehicles for discussing problems that are strictly detailed curriculum items.

The professional societies, in co-operation with the appropriate divisions, may also function in identifying significant new developments in the respective areas and in sponsoring studies of their impact on engineering education. These studies might be conducted by the individual divisions of ASEE, with further exploration in joint sessions and culminating in presentations at general sessions for the benefit of the entire membership of the Society.

Respectfully submitted,

C. A. Brown
E. C. Easton
Glenn Murphy, *Chairman*

VALPARAISO UNIVERSITY RECOGNIZED BY ECPD

Valparaiso University, Valparaiso, Indiana, was recently accredited by ECPD. Programs of mechanical, civil, and electrical engineering are offered. VU becomes the fourth school in Indiana recognized by ECPD. The other three are Notre Dame, Purdue, and Rose Polytechnical Institute.

STIMULATION OF CONTRIBUTIONS TO EDUCATIONAL INSTITUTIONS BY EQUALIZING TAX TREATMENT

The resolution proposed at the end of this report was adopted by the General Council at the June meeting in Berkeley.

The magnitude of the problem which faces the nation's colleges and universities, so that they may obtain the funds necessary to meet their future obligations, has already been sufficiently publicized so that it needs little documentation. For engineering alone the recently published report by ASEE's Committee on Development of Engineering Faculties predicts a need for an 80 per cent expansion in engineering teachers and $140 million more to pay the salary bill in 1967, without counting the cost of new facilities also required. ECRC's just published survey of *Engineering College Research Capabilities* indicates that an additional $10 to $25 million would be required in addition to the present $86 million being spent in order to realize the research potentialities of our *present* engineering faculties, with some $200 million in addition being needed for equipment and facilities. The President's Committee on Education Beyond the High School has predicted an annual need by 1970 for colleges and universities generally of more than double the approximately $3.4 billion spent in 1953 for current programs and plant expansion.

How will these large increases in cost be met? Traditionally this country has relied on a combination of means, both public (through taxation) and private (from voluntary contributions), in order to provide the basic support for higher education. There are many powerful reasons for continuing a balance among these sources. As the President's Committee stated: [1] "In the Committee's view, there is no one best source. Participation of each group, public or private, local or national, has virtues and limitations. Only a balanced combination of total effort will serve the need without creating imbalances in responsibility."

If we are to continue to have a balance between public and private sources of funds and to reap the many benefits which result from diversification in sources of funds, there is abundant evidence that private giving must be increased very substantially and very rapidly. However, there are real problems in achieving this objective. A recent report on *Stimulating Voluntary Giving to Higher Education and Other Programs* prepared by the Surveys and Research Corporation for the American Association for the Advancement of Science indicates that over the past 30 years, philanthropic giving averaged very close to 4 per cent of adjusted gross income of taxpayers, with practically no change from year to year even though in 1952 the ceiling on contributions was raised from 15 per cent to 20 per cent, and in 1954 anther 10 per cent for gifts to churches, educational institutions and hospitals was added.

There is increasing evidence to show that what is really needed for more private giving is a revision in tax treatment for contributions. Dr. Paul Klopsteg has stated the case succinctly when he says:

[1] *Second Report to the President,* The President's Committee on Education Beyond the High School, Page 75.

The curious if not startling fact is that the tax laws operate to increase greatly the ability to give of those whose income makes them most able to give and to diminish drastically the ability to give of those whose income already renders that ability low. The cost of giving for persons with a maximum surtax rate of 20 per cent is almost 9 times that for those at the 91-per cent maximum.

How does the disparity in the cost of the gift dollar arise? Consider one of the dollars given by the person whose highest surtax rate is 91 per cent. It is tax-free. But if he had not given it, government would have taken 91 cents, leaving him 9 cents. Thus the dollar he gave cost him 9 cents. By like process, we find that the cost of the dollar for one whose highest rate is 20 per cent becomes 80 cents.[2]

A revision in the tax laws to stimulate contributions has by now been considered and is being recommended by a number of sources. The President's Committee on Education Beyond the High School recommended [3] "that the Federal revenue laws be revised in ways which will even more strongly encourage larger contributions from more individuals to educational institutions. Partial credits against taxes due are a way to equalize the advantages in such giving between larger and smaller incomes."

The National Science Foundation has made a similar recommendation in its recent report *Basic Research, A National Resource.* The report on *Stimulating Voluntary Giving To Higher Education and Other Programs* prepared for the AAAS mentioned earlier indicates that as much as $4.5 billion might be realized in philanthropic giving generally (including churches, hospitals, etc. in addition to educational institutions) if an equalizing tax treatment plan for contributions were adopted. It is understood that the AAAS itself has gone on record in favor of the principle of equalizing tax treatment.

Based on this background, it is recommended that the General Council of the American Society for Engineering Education adopt the following resolution:

WHEREAS, it is abundantly evident that the funds provided for higher education, including engineering teaching and research, must increase substantially in the years ahead; and

WHEREAS, it is in the nation's interest that voluntary contributions as well as public funds should be increased to provide the necessary support;

NOW THEREFORE BE IT RESOLVED THAT

Federal tax laws should be revised to encourage greater voluntary contributions to higher education by reducing the relative cost of giving for those with low incomes to that realized by high income taxpayers.

Respectfully submitted,

RAYMOND J. WOODROW,
Vice President for ECRC

[2] Paul E. Klopsteg, "How Shall We Pay for Research and Education," *Science,* Nov. 16, 1956.

[3] See Reference 1, Page 90.

NEW MEMBERS OF ASEE

As of October 10, 1958

ALEXANDER, GERALD C., Assistant Professor of Electrical Engineering, Oregon State College, Corvallis, Ore. P. C. Magnusson, Louis N. Stone. E. E., Math.

ARMSTRONG, ROBERT H., Academic Advisor, Installations Engineering School, Air Force Institute of Technology, Wright Patterson AFB, Ohio. Clayton M. Zieman, Vincent S. Haneman, Jr. C. E.; I. E.

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BECKLEY, J. F., Associate Professor of Mechanical Engineering, Norwich University, Northfield, Vt. Alex W. Luce, Walter D. Emerson. Engr. Graph; M. E.

BENFORD, HARRY, Associate Professor of Naval Architecture and Maritime Engineering, University of Michigan, Ann Arbor, Mich. W. D. McIlvaine, W. J. Emmons. Naval Arch.; Engr. Econ.

BILLIET, WALTER E., Coordinator, Technical Education, Henry Ford Community College, Dearborn, Mich. Robert Kollin, John Ringelspaugh. Admr., Educ.; Tech. I.

BROWN, JAMES H., Associate Professor of Engineering, University of Omaha, Omaha 1, Neb. Sylvester V. Williams, C. H. Prewett. Gen. E.; Engr. Graph.

CAIRNS, JAMES R., Instructor in Engineering Drawing, University of Michigan, Ann Arbor, Mich. Herbert T. Jenkins, Frank H. Smith. Engr. Graph.; Mech. & Mat.

CALCOTE, LEE R., Associate Professor of Engineering, Arlington State College, Arlington, Tex. George Elton Smith, Oscar Rex Whiteside. C. E.; Mech. & Mat.

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TIPPITT, FRANK W., Assistant Professor of Industrial Engineering, Southern Methodist University, Dallas 5, Tex. C. H. Shumaker, I. W. Santry, Jr. I. E.; Math.

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ZUBALY, ROBERT B., Assistant Professor of Engineering, New York State Maritime College, Bronx 65, N. Y. John J. Foody, Thomas H. Bond. Naval Arch.; Mech. & Mat.

76 new members this list
124 new members previously added this fiscal year

200 new members this fiscal year

Know Your ASEE Officers (*Continued from page 373*)

JOHN GAMMELL

John Gammell, Treasurer of ASEE, received his B.S. degree from the University of Washington, Seattle, in 1928. He soon joined the Allis-Chalmers Manufacturing Company, where he currently is Director of Graduate Training.

Mr. Gammell has been associated steadily with Allis-Chalmers, as graduate student, sales representative, and Supervisor of Sales Training. Throughout, he has also been interested in organizations and committees associated with professional education and development.

For three years during World War II, he served in Washington as Chief of the Electrical Equipment Branch for the War Production Board. He has been a member of ASEE since 1949, is a registered professional engineer, and is active in other societies, including AIEE, ASME, and NSPE.

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